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TAMPERE UNIVERSITY OF TECHNOLOGY

EETU LEHTIMÄKI

CONCURRENT PROJECT PLANNING AND SCHEDULING IN A PROJECT BUSINESS COMPANY

Master of Science Thesis

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ABSTRACT

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This research studied project planning and scheduling in a project business environment and explored the challenges and opportunities of same topics in a project business company. The target company operates in marine and offshore industry handling project management together with engineering. Project sizes and scopes have varied and the grown project sizes have created a demand for more effective project planning. This was the basis for this study.

The research was carried out as a case study and performed with an action research method. It consists from a theoretical part where relevant literature is reviewed and from an empirical part with description of target company's current state and observed challenges together with alternative practices suggested for future projects. The literature review is based on articles and books written by experts in the field and the alternative practices are derived from these together with interviews conducted for this study. The description of current state and challenges was also created with knowledge from these interviews.

The main findings were that the project planning process suffers from insufficient communication and that the process needs more attention in order to improve. In addition, more resources are needed to operate the planning and scheduling system to meet the demands. To improve the process, understanding of internal customer relationship is promoted and knowledge management methods are suggested. For the challenges with project schedule, various techniques from Lean Project Planning and SMART Project Planning were recommended.

TIIVISTELMÄ

EETU LEHTIMÄKI: Samanaikainen projektisuunnittelu ja aikataulutus projektiliiketoiminnassa
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Tässä työssä tutkittiin projektisuunnittelua ja aikataulutusta projektiliiketoiminnassa sekä kyseistä liiketoimintaa harjoittavan yrityksen haasteita ja mahdollisuuksia samoihin aihealueisiin liittyen. Kohdeyritys tekee projektien johtamista ja suunnittelutyötä meriteollisuuden alalla. Projektien koko ja työn laajuus ovat vaihdelleet ja laajat projektit ovat saaneet aikaan tarpeen tehokkaammalle projektisuunnittelulle. Tämä oli lähtökohtana tälle tutkimustyölle.

Tutkimus toteutettiin tapaustutkimuksena ja tutkimusmenetelmänä käytettiin toimintatutkimusta. Työ koostuu teoreettisesta osasta, jossa asiaankuuluvaa kirjallisuutta on tarkasteltu, ja empiirisestä osasta, jossa on kuvattu kohdeyrityksen nykytila ja haasteet sekä ehdotettu vaihtoehtoisia käytäntöjä tulevaisuuden projekteihin. Teorian tarkastelu perustuu alan asiantuntijoiden kirjallisuuteen ja artikkeleihin, joihin vaihtoehtoiset menetelmät perustuvat tätä tutkimusta varten pidettyjen haastatteluiden lisäksi. Myös nykytilan ja haasteiden kuvaukset on tehty näiden haastattelujen pohjalta.

Puutteellinen kommunikointi projektisuunnitteluprosessissa ja prosessin vaatima suurempi huomio olivat tärkeimpiä löydöksiä. Lisäksi projektisuunnittelu- ja aikataulutusjärjestelmän hallinta ja ylläpito vaativat enemmän resursseja täyttääkseen vaatimukset. Sisäisen asiakkuuden ymmärtämistä pyritään edistämään ja tietojohtamisen menetelmien käyttöönottoa ehdotetaan projektisuunnitteluprosessin parantamiseksi. Aikatauluttamisen haasteisiin suositellaan tekniikoita Lean- ja SMART-projektisuunnittelusta.

PREFACE

This thesis was the final step for my graduation and a great milestone in my career. I would like to thank all who contributed in making of it. Especially, I would like to thank D.Sc. (Tech.) Heli Aramo-Immonen for the guidance and acting as the examiner of this research, Irmeli and Mikko for the support at target company and everyone who took part in interviews and discussions.

Turku, 16.8.2017

Eetu Lehtimäki

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LIST OF SYMBOLS AND ABBREVIATIONS

CPM	Critical Path Method
WBS	Work Breakdown Structure
KM	Knowledge Management
ETA	Estimated Time of Arrival
ICT	Information and Communications Technology
KPI	Key Performance Indicator
ERP	Enterprise Resource Planning
CMC	Computer-Mediated Communication
LPP	Lean Project Planning
EVM	Earned Value Management
LPS	Last Planner System
SBS	SMART breakdown structure
WIP	Work In Process

1. INTRODUCTION

The target company in this research is a global Finnish company in marine and offshore industry. The company's operations focus on project management and engineering.

1.1 Target company and industry

The target company was founded in Finland in the 1990's. Today it is an international organization providing accommodation and food handling areas for customers in marine and offshore industry. The company has offices and customers around the world and the construction work of projects is typically done near a shipyard that is building a vessel or a ship for example. This means that the company is able to execute projects where the customer wants and is therefore not dependent on locations of their own factories.

The construction work on sites is done by subcontractors and the target company provides supervisors and project management including project planners. In addition to this, the target company handles procurement and does most of the engineering for projects. A site team and office are organized separately for projects. Furthermore, the company has sales, marketing, human resources, finance and administration departments outside project teams.

In the past, the target company has done modernization projects and small scale new building projects covering interior outfitting for accommodation areas in ships. Recently, it has expanded to bigger new building projects including steel works, background outfitting and interior outfitting. This has brought challenges with new scopes of work such as steel construction but also a management issue as the sizes of projects has grown. Before, the project manager has been able to handle projects by himself but with big projects this is not effective or possible anymore. When the project scope is bigger, it becomes harder to control and monitor everything and thus effective project execution needs proper planning and control systems. These will help in decision making, forecasting, to make proactive actions and with handling the whole project.

Koskela (1992) has identified four peculiarities for shipbuilding and construction industry that set it apart from manufacturing:

1. One-of-a-kind nature of projects
2. Site production
3. Temporary organization
4. Regulatory intervention

One-of-a-kind projects have no prototype cycle, client input is unsystematic, coordination of uncertain activities is difficult and long-term improvement is questionable. Site production has external uncertainties like weather, internal uncertainties and complexities like flow interdependencies and changing layout and transferring improvement across sites is difficult. Temporary organization has internal uncertainties like exchange of information across organization borders and again transferring improvement across organizational borders is difficult. Eventually, regulatory intervention means external uncertainty like approval delays. In addition to these, Emblemsvåg (2014a) adds a fifth peculiarity for shipbuilding. Most ships are put into engineering and production before all engineering issues are solved. This is a consequence from technical complexity in combination with the importance to offer short delivery times. In summary, shipbuilding for the offshore market segment has challenging peculiarities. In particular, almost every production has a very demanding design and engineering of a technologically advanced solution taking place. This makes planning and execution demanding.

1.2 Current project management and procurement/logistics software

The target company is currently using Oracle's Primavera P6 Enterprise Project Portfolio Management, in short Primavera, for project management. The software can be used without internet connection as a "stand-alone"-version but usually it is connected to a database shared with all users in the company. All changes made to a project in P6 are automatically updated to the database and thus separate savings are not needed. The company has also integrated Oracle's BI Publisher application to Primavera. This is a reporting tool used for example to provide visual charts for progress reports. BI Publisher uses the data from P6 to create documents.

Primavera has traditional structure for project management which includes work breakdown structure (WBS), activities, resources and roles. The interface has many different layouts and users can modify and save their own layouts as well. Figure 1 shows a common layout being used that has three areas. One shows the WBS and activities with columns like start and finish dates and percentage complete, another one next to it shows a Gantt chart for the activities and below these two is information about selected activity. This information contains for example activity type, duration type, calendar, resources, roles and relationships to other activities.

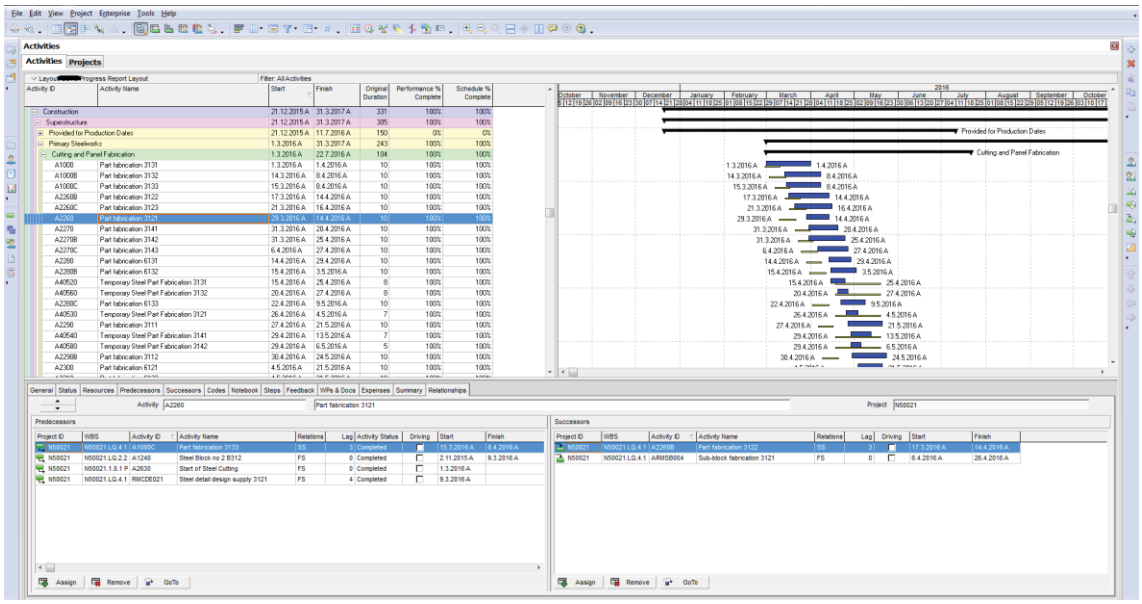

Figure 1. *Primavera P6 interface*

Primavera P6 is designed for enterprises that need to manage several projects simultaneously and to have support for multi-user access. The application tracks projects, portfolios and resources capturing related costs, issues, risks and performance metrics during their full life cycles. With P6 it is also possible to use project templates which enable the reuse of projects in full or in part. (Primavera P6 User's Guide 2013)

Procurement and logistics departments have their own software for monitoring materials and their delivery. The software is developed by the target company and is being refined continually with the users' help. One of the latest updates was a report layout for Primavera progress updates as seen in Figure 2. The project planners can use this to import data to Primavera as it includes the activity codes which can be used to identify and match the rows with Primavera. However, this process requires the use of Excel before the data is suitable for Primavera.

Primavera activity	Project	Status	Area	Order	Supplier	Item	Quantity	Delivery date	Confirmed del. date	Pick up at	Ent	Needed on site	CONTAINER				Info / comments
													Name	Shipping	ETA	Qty	
A2280	[redacted]	Arrived		919098	[redacted]	[redacted] duct heaters	203 PCS	2.1.2017		[redacted]	OY		517488	17.10.2016	18.10.2016		
A2280B1	[redacted]	En route		919098	[redacted]	[redacted] duct heaters	224 PCS	5.5.2017		[redacted]	OY						
A2040	[redacted]	Arrived		919293	[redacted]	Corian cabinets batch 1	112 PCS	3.11.2016		[redacted]	OY		517298	10.10.2016	11.10.2016		READY EARLIEST 6.1
A2040	[redacted]	Arrived		919293	[redacted]	Corian cabinets batch 1	112 PCS	3.11.2016		[redacted]	OY		517444	13.10.2016	14.10.2016		READY EARLIEST 6.1
A2040B1	[redacted]	Arrived		919293	[redacted]	Corian cabinets batch 2	112 PCS	9.1.2017		[redacted]	OY		519631	22.12.2016	23.12.2016		
A2040B11	[redacted]	Arrived		919293	[redacted]	Corian cabinets batch 3	56 PCS	17.5.2017		[redacted]	OY						
A2040B21	[redacted]	En route		919293	[redacted]	Corian cabinets batch 4	56 PCS	19.6.2017		[redacted]	OY						
A1120	[redacted]	Arrived		919354	[redacted]	cabin wall panels batch 1	45 SET	3.11.2016		[redacted]	OY		517191	7.10.2016	10.10.2016		READY EARLIEST 6.1
A1120B1	[redacted]	Arrived		919354	[redacted]	cabin wall panels batch 2	45 SET	9.12.2016		[redacted]	OY		518355	11.11.2016	14.11.2016		

Figure 2. *Report layout for Primavera*

The software has information about the materials like name, order number, supplier, quantity, estimated time of arrival (ETA), etc. which can be seen in Figure 3. The gray rows mean that the items have arrived and the logistics coordinator on site has recorded it.

Row	Area	Order no	Supplier	Item	Size	Amount / Qty	Delivery date	Confirmed del. date	Pick up at	Ent	Needed on site	CONTAINER Name	Shipping	ETA	Qty	Info / Comments	Primavera activity
1		919098	[redacted]	[redacted] duct heaters		203 PCS	2.1.2017		[redacted]	OY		517488	17.10.2016	18.10.2016	221		A2280
2		919098	[redacted]	[redacted] duct heaters		224 PCS	5.5.2017		[redacted]	OY							A2280B1
3		919293	[redacted]	Corian cabinets batch 1		112 PCS	3.11.2016		[redacted]	OY		517298 517444	10.10.2016 13.10.2016	11.10.2016 14.10.2016	55 57	READY EARLIEST 6.10.2016 / Partial shipment	A2040
4		919293	[redacted]	Corian cabinets batch 2		112 PCS	9.1.2017		[redacted]	OY		519631	22.12.2016	23.12.2016			A2040B1
5		919293	[redacted]	Corian cabinets batch 3		56 PCS	17.5.2017		[redacted]	OY							A2040B11
6		919293	[redacted]	Corian cabinets batch 4		56 PCS	19.6.2017		[redacted]	OY							A2040B21
7		919354	[redacted]	cabin wall panels batch 1		45 SET	3.11.2016		[redacted]	OY		517191	7.10.2016	10.10.2016		READY EARLIEST 6.10 / [redacted]	A1120
8		919354	[redacted]	cabin wall panels batch 2		45 SET	9.12.2016		[redacted]	OY		518355	11.11.2016	14.11.2016			A1120B1

Figure 3. *Material follow up software*

1.3 Definition and perspective of the research subject

In this research the target company's challenges with project planning and utilization of project schedule in different departments is being reviewed. These departments are engineering, procurement, production and project management. The subject is limited to project planning and control throughout the company with the main focus on better forecasting and proactive control.

The focus in this work is to examine how different departments are using the project schedule and what kind of challenges they are facing and if they have any development ideas. In addition, the benefits and effects of a good project schedule are being examined. The goal of this is to point out the meaning of project schedule and the effects of individual's work on the work of others in a project to the whole project organization and how important it is for every department to follow the same path and guidelines.

The theoretical frame of reference and **analysis perspective** is on knowledge management, internal customer relationship management and project control. Research material includes interviews with target company's employees and scientific publications and books about the research subject. The purposes of these are to find out current state and challenges in the target company and findings or opinions of the experts and specialists. The employees usually have the best knowledge about their own departments and possible problems and development areas in there. The experts' theories will give opinions on how to solve these problems and create better processes for building and utilizing project schedules.

The **research subject** is based on the acknowledged need for better proactive project control and forecasting with project schedule. This need is a result of growing project sizes and the help of project planning is needed especially in production for controlling the subcontractors and being able to forecast a few weeks ahead. Project management also needs a better forecast for risk and change control. Moreover, these demands reflect to other departments.

1.4 Research strategy and method

This research is carried out as a *case study*. Case study is a form of qualitative descriptive research that emphasizes exploration and description instead of discovering a uni-

versal, generalizable truth. The goal is to provide as complete understanding of the situation as possible. Once the data and information has been collected it is analyzed. The interpretations are made holistically attempting to draw conclusions based on the data (Colorado State University 2012). Yin (1989) defines case study as an empirical inquiry that:

- Investigates a contemporary phenomenon within its real-life context; when
- The boundaries between phenomenon and context are not clearly evident; and in which
- Multiple sources of evidence are used.

Case study is preferred in examining contemporary events when the relevant behaviors cannot be manipulated and the research question asks 'how' or 'why'. It relies on observations, interviews, documents and artifacts as the sources of evidence. However, in some situations participant-observation and informal manipulation can occur. Consequently, case study is a way of investigating an empirical topic by following a set of pre-specified procedures. (Yin 1989)

In this case the unit of analysis is an event. More specifically, it is the project planning process in the target company. In this research, the data is collected by interviewing employees of the target company from different departments. These can be considered as expert interviews since the focus is on their own work processes and the answers are describing their working methods, challenges and development ideas. With this data, the research problem can be studied from an empirical basis and moreover, the data gives experiential knowledge for the analysis. With this knowledge and literature, conclusions are made for creating solutions to the emerged issues.

The method for this research is participatory action research. It is a qualitative research methodology which practices the idea that research must be done 'with' people instead of 'on' or 'for' people. Qualitative research integrates the methods of observing, documenting, analyzing and interpreting characteristics, patterns, attributes and meanings of a phenomenon under study. Ideally, the purpose of participatory action research and of all action researches is to impart social change with a specific action or actions as the ultimate goal. Moreover, objectives are to change prevailing practices and to solve problems. Furthermore, the actors are taken as active participants in the research and the researcher participates in operations and daily activities at organization. In conclusion, participatory action research is a way to take action to address problems and issues in communities with fostering collaboration among participators and researchers. (Chevalier & Buckles 2013; Kuula 1999; MacDonald 2012)

1.5 The research problem, research questions and objectives

The **research problem** is associated with controlling decision making and basis of all operations in every department. This means there has to be a common tool for everyone

to follow and get support from. In this case that is the project schedule. Based on this research problem the **research question** is: *What kind of challenges are faced in the organization and what are the root causes of these challenges (i.e. why they exist)?* And further, *How to overcome these challenges?*

The **main objective** of this work is to find out what is needed from the project schedule to become the basis for all operations and decision making in projects and how to get the project schedule utilized more effectively. With these findings, the target company could get rid of decisions based on individual feelings and conclusions and move into a more standardized practice where every operation and decision would have the support of project schedule. Furthermore, changes that take place in a project should be driven through project schedule to have better forecast and control of risks.

To reach the set objectives, *current state* of the examined process is defined. Next, the *challenges* in the target company are clarified. Last is to create an *alternative way to work*.

2. PLANNING AND CONTROL IN PROJECT ORGANIZATION

Project planning plays critical and important part in project success. Hartman & Ashrafi (2004) phrase it is widely recognized that poor project planning is often a significant cause of project failure. Root cause analysis of Hartman's & Ashrafi's (2004) study suggests that some sort of communication breakdown is usually triggering these project failures. Thus, there is still dissatisfaction with the current state of project planning processes and tools and as good planning is the foundation of project success, it is reasonable to focus on the planning phase of project to enhance success. (Hartman & Ashrafi 2004)

Project management needs accurate and timely information to plan, track and control the project to meet set objectives. Sometimes companies resist using planning and controlling techniques because of the additional management costs but lack of information can actually become even more expensive if it leads to poor decision making. Here are listed some of the benefits associated with project planning and control:

- The process of creating a plan forces people to think about what is involved in the project and their interdependencies.
- Without a plan, things will be forgotten, started late, or assigned for several people to do.
- A properly thought through plan is one of the few defenses against requests for unreasonable deadlines.
- **Estimating:** The data used for estimating is gathered from previous projects. If this is not done the data may be lost forever and forecasting loses accuracy and becomes more difficult.
- **CPM:** Critical Path Method gives managers a structured manner for planning and points out the critical activities. If there is a plan against which progress can be tracked, then divergence can be spotted and action taken before the situation becomes critical.
- **Quality vs Quantity:** Reports are required to be structured and summarized. Otherwise too much data and insufficient information may be generated.
- **Response Time:** It is essential for effective project control to have timely response on project performance. Feedback can be adjusted to address the project's needs.
- **Trends:** Project control can be improved by monitoring the progress trends of time, cost and performance.
- **Cost of Mistakes:** Without an effective planning and control system the cost of mistakes due to lack of adequate control may rise high.

- **Procedures:** Planning and control system enables managers to create procedures and work instructions tailored to specific needs.
- **Client:** When reporting and holding meetings with clients the planning and control system provides information about different aspects of the project. A plan is a communication tool for stakeholders to get a common understanding of when outputs will be available and why certain deadlines have to be met. (Burke 1995; Nokes et al. 2003)

In addition, special knowledge about how to sequence activities in company's field of projects often represents their core competencies. This is what customers want and are ready to pay for. (Gardiner 2005)

2.1 Project planning

Project planning is in the center of project management in many ways. In planning a complete understanding of project's requirements is brought together with a deep understanding of all elements that are required to conduct a successful project. In addition to planning, estimating and resourcing need to be carried out in parallel as they directly affect each other. Planning is defining the work to be done that includes dependencies, timing and resource requirements. In other words it is a description of how to reach an objective (Nokes et al. 2003). Estimating is calculating the amount of time and effort that will be required for each part of the work to be done per type of resource. Resourcing is distributing actual resources to the plan. As resources are limited and the quantities required may change from what was planned or have competing demands, it may be necessary to make compromises and reallocate resources. Thus, there will inevitably be changes in durations and timings of activities. Furthermore, there may be impact on the project's predicted costs. (Wallace 2016)

It is very difficult and almost impossible to know precisely all the activities in a project at the preliminary planning phase. Even with a good knowledge about the activity structure the activity durations and costs will be challenging to estimate. Defining the activity parameters comes even more arduous when they are dependent on the outcome of earlier activities in a chain. Decisions made for activities without proper knowledge can result in less than optimal solutions. According Andersen (1996, p. 89) the focus at initial planning stage should be on what kind of results the project should achieve. With activity planning planners need to make decisions early in the project when little is known about the actual work that is going to be done. This means that the planners will choose early solutions and not optimal solutions. Sometimes planners make vague descriptions of activities when there is uncertainty and it leads to poor estimating and forecasting. This also becomes a way of hiding the real issues confronting the project. (Dvir et al. 2003; Andersen 1996)

As an alternative for activity planning Andersen (1996, p. 90) suggests milestone planning. In this case milestone is defined as a result to be achieved. It is a description of a state or condition that the project should reach by a certain point in time. In other words, milestone describes the goal but not the ways to get there. It answers to 'what' before considering 'how' meaning that in the initial project planning stage the results to be achieved are discussed and agreed first. A milestone plan covers the end results as well as the intermediate results necessary to complete the project. After agreeing on this plan the means and methods to achieve the results are considered. This is when for example most suitable activities to obtain the results are discussed. (Andersen 1996)

Common method for planning is to start from high level summarization of work to be done and move on to more detailed tasks as the planning process proceeds. This is called top-down approach. Often this dividing into details stops at relatively high level in the initial planning and the expansion to complete details is done only shortly before each new phase of work. Top-down approach is a logical way to think about a project and often a good approach for new endeavors as it provides an early high level plan with initial costs and timings. Bottom-up approach means the opposite and it is useful when there is a similar project plan available from an earlier project. If the earlier project was successful it is reasonable to use that plan as a starting point. Besides saving time in the planning process this allows to learn lessons from the previous project like making estimations deduced from previous experiences. In bottom-up approach there is a fully detailed plan from a previous project which will then be adjusted with precise details, estimations and dependencies for a new project. With a full detailed plan in the beginning, the plan needs to be summarized and then be used for project definition and reporting purposes for example. (Wallace 2016)

When using the top-down approach in large projects the extension to details should be done in stages. There is no need to know precise details far in advance as it is no relevance. Besides, too many details too far ahead means they are most likely wrong and are going to change anyway. Furthermore, there are more important tasks to be done during the project definition and launch than going into too much details with precise timing of events in distant future. It is clear that details are needed beforehand for allocating people to different tasks and mobilizing resources required. The extension to details should be done for each phase of work together for all related issues which means that the work should be divided to logical phases. The first phase should be planned right after the project definition and the following planning towards the end of previous phase of work. (Wallace 2016)

One of the biggest issues and disagreements in project management is the level of details in project plan. Some argue that it should be scarce and summarized with key information and others want full details of every individual's all tasks. Usually only project manager and project office team are interested in full details of a plan besides project team members who need to see details related to their own activities. Project spon-

sors and other shareholders are often interested only in key summary information like milestones and overall costs. In Table 1 some factors of a small and large plan are considered.

Table 1. *Project plan factors to paraphrase Wallace (2016)*

Factor	Small plan	Large plan
Constructing the plan	Low effort / short time	High effort / long time
Identifying dependencies	Will be at high level hence may be inefficiencies and missing links	Can be fine-tuned for perfect automatic scheduling
Identifying resources	Probably need to assign groups of people to deliver high-level tasks collectively	Can accurately assign individual people to individual tasks
Tracking progress	Low effort but possibility of issues being hidden	High effort – but accurate
Reporting progress	May be usable without summarization	Will need to be summarized for reporting purposes

Any of the alternative approaches to a plan can be valid in right circumstances and it is important to modify the plan for the needs of different persons for example with filters and layouts. Sometimes it is appropriate to divide a large plan into smaller sub-plans for different teams. The optimal approach is hard to judge and it is usually dictated by the norms in organization and previous plans that has been used as basis. The key is to discuss and agree about the strategy with project sponsors and others concerned. (Nokes et al. 2003; Wallace 2016)

2.1.1 Lean Project Planning and Last Planner System

Lean Project Planning (LPP) combines lean thinking, earned value management (EVM) and last planner system (LPS). It considers planning as a communication process and focuses not on the plan per se (Emblemsvåg 2014a). In this context the lean thinking is represented by the Plan Do Check Act (PDCA) –cycle which is used for problem solving approach. This includes making problems visible, finding proper solutions, checking the results and acting on deviations (Halse et al. 2014). EVM method is probably the most common project planning and reporting tool. It gives a measure that brings togeth-

er time and cost performance elements into a monetary quantity (Maylor 2010). With the use of cost performance index (CPI) the cost at completion can be estimated relatively well. However Emblemsvåg (2014a) points that EVM suffers from a limiting assumption that activities and cost accounts are independent which can cause unreliability of work flow and Fleming & Koppelman (2005) states that EVM can be too complicated for many to master. The LPS promotes detailed planning carried out by those who perform the activities being planned (Maylor 2010). These are usually 4-6 weeks look-ahead schedules that contain detailed information of activities and their dependencies that are normally not identified at higher levels of planning. On the other hand, Emblemsvåg (2014a) identifies particularly the linkage upward to the higher-level plans for keeping track of progress as a problem for the LPS. As a solution to overcome the issues with EVM and LPS and to combine the strengths of both, an alternative called LPP was developed (Emblemsvåg 2014a).

The LPS tries to bring the benefits of lean manufacturing into project work. It has three hierarchical levels called initial planning, look-ahead planning and commitment planning. Initial planning provides project budget and schedule and pushes completions and deliveries onto the project. Look-ahead planning takes resources into account and by that further adjusts and details budget and schedules. Commitment planning is evaluating what can be done with the actual situation in mind and comparing this to what should be done. Based on this evaluation people commit themselves to the plan and this is the beginning for production control. This process is described in more details in Figure 4.

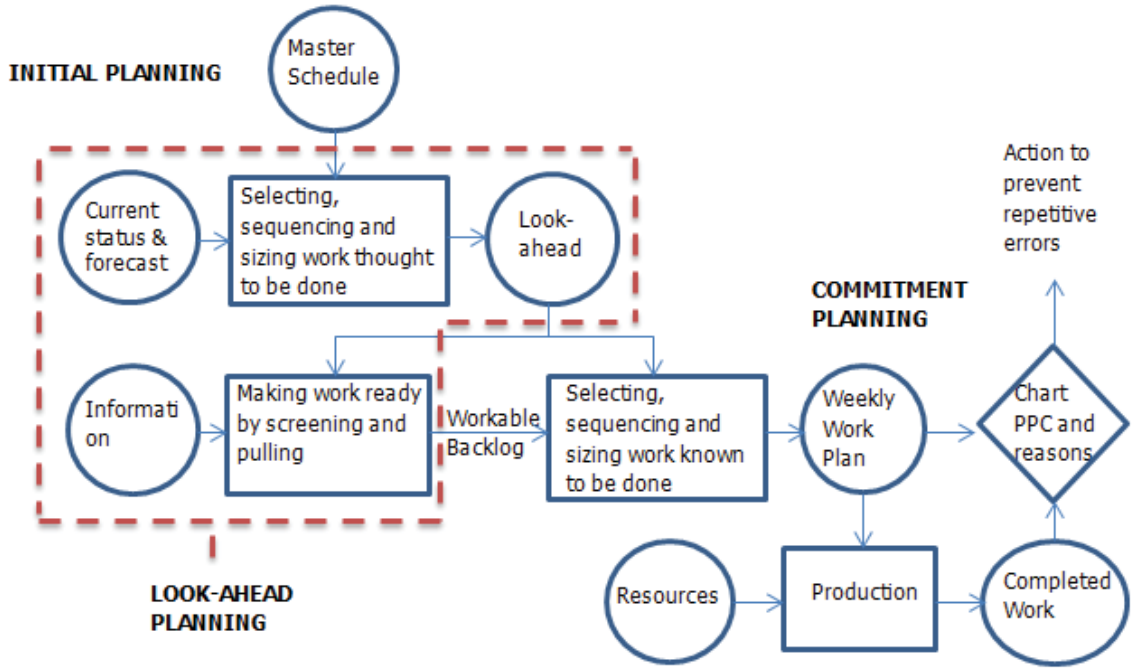

Figure 4. *LPS levels as a process to paraphrase Ballard (2000)*

There are some important notes to make about the look-ahead planning. The look-ahead plan is more detailed than the master schedule as it expands the activities into defined work packages and operations and also sequence together with rate from the master schedule can be improved and adjusted closer to realities. As the methods for executing are more detailed, work flow and capacities can be matched. The possible assignments in the look-ahead process need to be identified 3 – 12 weeks in advance depending on project characteristics such as planning system's reliability, lead times for information acquiring, materials, labor and equipment. The purpose is to make sure that only activities that can be completed on schedule will advance from one week to the next and eventually into production. This creates a backlog of executable activities. For this to work, constraints must be analyzed and removed. An assignment is defined by Ballard (2000) as the plan of what physical, specific work is to be done tomorrow and the person producing such assignment is called as the "Last Planner". There are also important notes to make about the commitment planning which is the phase where the weekly work plans are made:

- The assignment must be unambiguous so it is clear whether the assignment is completed or not at the end of the week.
- The assignment must be executable. This means that nothing from the seven preconditions that Koskela (2000) has identified is not missing. These are construction design (information), components and materials, workers, equipment, space, connecting work and external conditions like weather, government rules and licenses.
- To avoid rework, the assignments must be defined in the correct order of sequence.

- The assignments must match with available capacity.
- The assignments not completed as planned must be used for learning to prevent similar mistakes to happen in future. (Ballard 2000; Emblemsvåg 2014b)

The LPS uses a measure called Planned Percent Complete (PPC) to keep track of how well the project is being executed (Emblemsvåg 2014b). Maylor (2010) explains it as a percentage of activities completed divided by intended completed activities. According to Ballard (2000) the PPC on non-lean processes is typically between 35% - 65% while after LPS implementation the performance is between 75% - above 90%.

Emblemsvåg (2014b) has summarized some conclusive differences between EVM and LPS:

- The flow of materials and information is controlled with pull techniques in LPS, whereas EVM uses push-oriented techniques for releasing the information and materials.
- In EVM project control relies on variance detection after-the-fact, while control in LPS is obtained via execution.
- To minimize variation capacity and inventory buffers are used. In LPS feedback loops are used at every level to make quick system adjustments, whereas EVM does not include adjustments.
- In EVM variation mitigation and management is not considered but LPS tries to mitigate variation in every aspect.
- Decision making in LPS is distributed whereas in EVM it is more centered and sometimes to only one manager.
- A buffer of assignments is maintained for each crew or production unit. In comparison, EVM method does not consider a backlog.
- As EVM promotes optimization of each activity, LPS production system design tries to avoid local sub-optimization.
- EVM considers project management at the macro level and LPS involves both project and production management.

As a conclusion EVM is good at handling big issues in project planning but it fails at important issues concerning improving project performance relevant to supervisors. In contrast, LPS is good at what EVM fails at but does not handle the bigger issues as well as EVM. However, both of these approaches fail at handling advanced engineering design work. This is because they have not managed to identify ways of measuring physical progress in engineering. (Emblemsvåg 2014b)

LPP overview is presented in Figure 5. The planning has been divided to system part and planning process part. The system part in here is implemented in Primavera P6 and the planning process is derived from LPS thinking with elements from EVM as well.

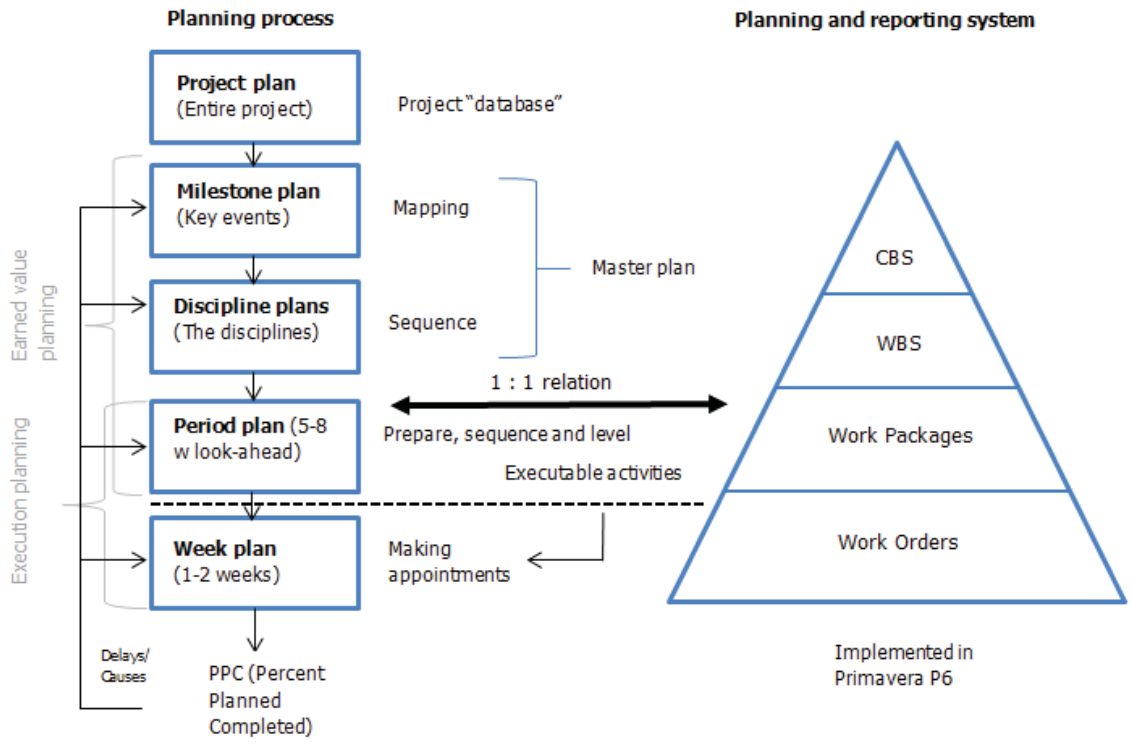

Figure 5. *Lean Project Planning overview according to Emblemsvåg (2014b)*

On top is the project plan. It contains the entire database found in IT tool which only the planner sees. Thus it does not constitute a plan from a communication point of view. After this the first plan is the milestone plan that consists of key events in the project. Second is the discipline plans that covers major disciplines and in which the activities are sequenced to work effectively and to prevent non-value-adding work. These two plans together constitute the master plan and cover the whole project execution horizon. The period plan also includes the entire project scope but its usage and execution focus on looking ahead 5 – 8 weeks continuously. At period plan level the EVM and LPS combination takes place as it facilitates the LPS's look-ahead functionality and improves the reliability of EVM. Naturally, long lead time items are followed up prior to the 8 week horizon. The EVM and LPS combination is attained operationally by defining work packages in 1:1 relation to activities in the period plan. This gives a good way to track physical progress as the CPI's give physical meaning to the supervisors. This makes also the EVM difficult to manipulate which has been an issue according to Kim & Ballard (2000). Relation between discipline and socialization is important and a combination of IT systems and social cooperation from disciplines is used in order to avoid that the system is not gamed and the Work In Process (WIP) is controlled. This explicit control of WIP makes the LPP system acceptable to the lean principles and hence justifies the use of term "lean". (Emblemsvåg 2014a; 2014b)

LPP includes weekly lean meetings where most committing coordination and communication take place. These meeting are focused, short and highly effective and have some compulsory elements:

- Attendance is mandatory and attendance sheets are used.
- Participants must come prepared. Lack of preparation results in postponing the meeting as long as everybody is prepared.
- Line management joins the meetings some times.
- Participants will explain what they have done last week, what has deviated from the plan and how these deviations are going to be handled.

It is important that these elements are communicated in advance. According to Emblemsvåg (2014b) after a while people will accept this as normal and also promote it themselves. Furthermore, they will understand that a discipline is necessary to keep the meetings focused and highly effective. (Emblemsvåg 2014b)

In addition to before mentioned the purpose of look-ahead in the period plan is to make detailed sequencing and level the production. Detailed plans are common in many companies and it is believed that it creates effective execution (Emblemsvåg 2014b). However, Taguchi et al. (2005) argue that a process that has a certain degree of inherent uncertainty will not perform better by squeezing it into too detailed activities. The processes must be less prone to random variation first to make more detailed planning useful. Thus, it is more important to train organization to accept uncertainty and to rely on the expertise of supervisors and coordinators to find the best solution at given circumstances. For this to work, planning must primarily be a process of communication (see chapter 2.5) at the lower levels of the planning system. The week plan is essentially a work list for supervisors and their teams across disciplines and this planning level has few important functions:

- Week plans are communication and coordination tools. No amount of detailed activities in a planning system can replace talking to each other and it is this part of the planning where communication is very important.
- Weekly lean meetings are where the earlier mentioned commitment planning of LPS happens. Project team members go through what needs to be done, when and in what sequence. In addition, emerged problems are dealt right there and then.
- The week plans' regular status reviews, important for performance, also take place in lean meetings. As many companies use the Plan-Do methods, the real success lies in the follow-up and thus using the whole PDCA cycle. (Emblemsvåg 2014b)

In monitoring the project execution PPC from LPS is used and s-curves together with CPI from EVM is used to keep overall track of the project. Emblemsvåg (2014a) points out that low PPC's typically result in low CPI over time and thus PPC is actually a good Key Performance Index (KPI). Furthermore, LPP has some principles that differ from other planning approaches. One of these is making detailed plans only until approaching execution and not too early. This is to reduce rework on planning and hence saving effort and time wasted on updating detailed plans before realistic planning horizon. Another principle is that planning must be done by the ones who know the jobs. This is derived from lean principles and means in other words, that supervisors and coordina-

tors are an integral part of the planning process. Consequently, the planner is not setting dates, defining durations or giving hour consumption estimates without the input from those responsible or from previous projects with similar scope. The planner facilitates the planning process, manages the planning tool, analyzes reports and so forth. (Emblemsvåg 2014a)

2.1.2 SMART Project Planning

SMART is an acronym for Strategically Managed, (stakeholders, management processes and other factors) Aligned, Regenerative (teams) and Transitional (world). One of the key elements in SMART Project Planning is to set and manage realistic expectations by recognizing and clearly articulating the uncertainty inherent in planning. Another key element is to plan based on how people manage rather than obliging project teams to try to manage the way people plan. The latter usually results in practical disconnect between planning and doing. The SMART framework takes into consideration the importance of the following factors highlighted by project management researchers and practitioners:

- There is a need to quantify and justify value for money – Return On Investment
- A balanced score card approach helps target success criteria at the front end of a project.
- Alignment with corporate strategy is important.
- Meeting or exceeding stakeholders' requirements and expectations is a prerequisite for perceived project success.
- Success criteria should be clearly defined at the outset of the project
- Simplification, standardization and integration of tools and processes are necessary.
- Alignment of the perception of success and expectations of stakeholders is needed throughout the project management process from inception to completion. (Hartman & Ashrafi 2004)

The SMART approach has been developed in response to demand for better ways in delivering projects. It consists of tools, processes and competencies. The tools are mechanisms for planning and executing projects effectively. The processes show ways to utilize the tools for different projects depending on the size, complexity and uncertainty for example. Ultimately, the competencies add and deploy the knowledge, experience and skills that make a project team successful. Finally, the SMART approach advocates balance between business issues, technology and social issues. According to Hartman & Ashrafi (2004) the SMART Project Management framework provides an integrated solution considering business, technology, processes together with project drivers, team effectiveness, communication and stakeholders' concerns. (Hartman & Ashrafi 2004)

The SMART Project Planning framework was developed by studying the tools and practices used by good or exceptional project managers, enterprises or industries and by looking at the primary causes of failure. The key considerations for development included the following issues:

- The process of building a plan should nurture an effective team, trust, open communication, creativity and a shared vision of success.
- Planning needs to be completed at an appropriate and credible level of detail to accommodate the realities of uncertainty and increasing complexity.
- The plan should be easy to track performance against and to adapt to actual conditions without compromising the intent and success criteria of the project.
- Stakeholders' expectations need to be met or managed from the beginning and all along the life of a project. Alignment of stakeholders is important and should be confirmed and tested.
- The plan should be formulated based on deliverables as they are normally the basis on which to manage, measure and monitor.
- Risk and uncertainty need to be reflected in the plan. Risk needs to be managed or mitigated. Uncertainty needs to be acknowledged in budgets schedules and other elements of the plan, including performance outcomes or key results. Stakeholder expectations need to be managed to accommodate the real uncertainties of today's projects.
- The project charter and the project plan need to be synonymous to be effectively implemented.
- The plan needs to have flexibility built in to accommodate inevitable changes with a minimum disruptions and surprises for stakeholders as possible.

These considerations led to the development or adaptation of tools needed to support the planning framework. (Hartman & Ashrafi 2004)

There are four aspects in the SMART framework for managing projects that were mentioned in the acronym. *Strategically managing* means tools that help identifying and selecting the projects that should be funded and proceed. Special milestones are used as stage gates where the projects are revalidated and the next round of funding is provided or the project is modified or cancelled. Stakeholders with the objectives of the project, team members with the project plan and the priorities for the project with the metrics to be used for control need to be *aligned*. Without this alignment there will be rework and unnecessary activities in the project. A *regenerative team* has these features: open communication, ownership of job, a propensity to take risk, a high level of trust, fun in the workplace, creativity and tribalism. The *transitional world* describes the need to manage complexity, uncertainty, change and risk. There are several tools to help doing this but the most important is the management of stakeholders' expectations. Once the project and its environment (inevitably) change the best project managers spend substantial amount of time to keep stakeholders informed of the changes and their impact on the project. (Hartman & Ashrafi 2004)

Project charter is essential to the SMART Project Management planning framework. This charter is both the project team's license to spend client's money and the project plan. Hence it has to answer the relevant questions that buyers are entitled to have answered. As a framework to develop these answers the charter uses several devices. Four core devices of these are SMART breakdown structure (SBS), priority triangle, three key questions and RACI+ charts. SBS is similar to a work breakdown structure (WBS) viewed later with some differences. At the top level of SBS is the mission of a project defining the problem that is meant to be solved and providing a link to buyer's objectives or corporate strategy. The second level points out key stakeholder groups, their expectations and the outcomes that will lead to achieving the mission. This helps identifying conflictions between stakeholders at the beginning of a project rather than near the end of it. At the third and subsequent levels the tangible deliverables that will be produced by the project team will be identified. These deliverables are meant to meet or support the expectations pointed out at the second level. In addition, SBS includes exclusions and parked items. Exclusions define what will not be delivered and parked items are those that are uncertain and not yet known what to do with. When approaching the end of a project the parking lot should be empty. In addition, if there is no connection between the project mission and the objectives of the buyer or sponsor, the project should be cancelled. Moreover, the SBS is not developed just by the project manager or project planner, but by the team. With SMART Project Management the team also includes client, key subcontractors and suppliers together with other important stakeholders. The stakeholders at SBS level two are also ranked in order of importance and influence to the project and the stakeholders will agree to this order later themselves. This helps in the management of expectations and priorities. Furthermore, the SBS makes some key connections. One of these is between the project and corporate strategy and another between stakeholders and conflicting expectations but the most important one is the link between key results, the stakeholders who have a particular interest in them and the deliverables that define their achievement. (Hartman & Ashrafi 2004)

Priority triangle is an inverted triangle with three dividing lines across the center point as seen in Figure 6. Each corner has a letter presenting one priority and the "X" shows the order of priorities depending where it has been set. In here it shows P as the most important, T as second and C as third in priority. P means performance, T means time and C means cost. Performance in this case is a combination of scope and quality. There are six possible permutations for project priorities which all imply a different approach on how to plan and manage a project.

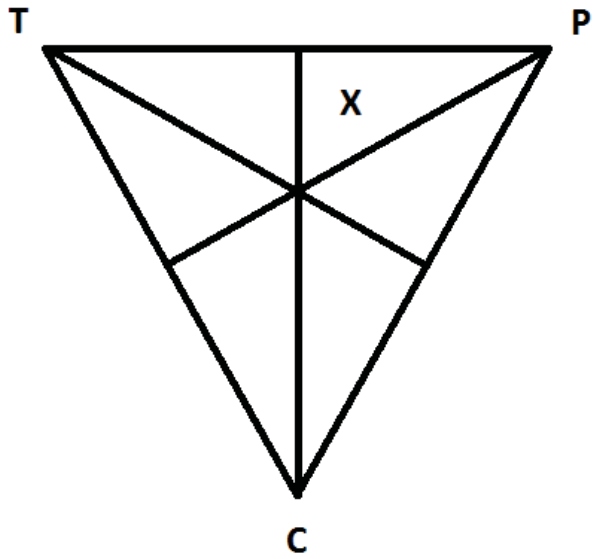

Figure 6. *Priority triangle to paraphrase Hartman & Ashrafi (2004)*

The priorities for a project should be developed with the team. Hartman & Ashrafi (2004) have noticed though that individuals in the team will usually select most of the priority permutations. The process is to find out which one of the permutations is right for the project and then work with the stakeholders that had different priority permutations to align their interests with the rest of the team. Furthermore, the triangle is inverted in order to remind that the changing priorities need to be balanced throughout the project. A project may have different priorities for different phases and identifying these will help knowing which elements should be on the critical path and which not. (Hartman & Ashrafi 2004)

The three key questions confirm what is learned in development of the SBS and address fundamental issues relevant to understanding the project objectives. The three questions are:

- What is the final deliverable for this project? (Delivering this defines the successful completion of the project.)
- What is everyone praising this project for? (The success of this project is directly proportional to the measures of success of these results.)
- Who will decide the answers and the outcomes of the first two questions? (Have the right stakeholders and their key results been identified in the SBS?)

According to Hartman & Ashrafi (2004) the answers to these questions are not simple or obvious. A common challenge is for example that everyone knows the planned finish date for the project but they do not agree on what is the trigger for this. Another issue is that something important to stakeholders is not measurable. Therefore the success of the project cannot be measured and it becomes a matter of opinion. Missing a key stakeholder in the development of the SBS can also become an issue. This may lead to rethinking of priorities, scope and other factors affecting the project plan. Finally, aligning

the priorities for a project element driving planning, scheduling, estimating, risk management and other steps produces a more robust plan with less conflict and often, with better ownership of the plan by the project team. (Hartman & Ashrafi 2004)

RACI+ stands for Responsibility, Action, Coordination and Information. The "+" means additional information that has been added in SMART framework to make the chart more useful. The additional elements are for example a short term schedule normally in the form of Gantt chart and work hour budget for each deliverable. Also, the production schedule is for deliverables instead of activities which means that a product is delivered at the end of each bar in a Gantt chart. As communication breakdowns are one of the primary causes of project failure, understanding the use of RACI+ charts and promoting awareness of communication significantly reduces these communication issues. (Hartman & Ashrafi 2004)

As a conclusion Hartman and Ashrafi (2004) made six observations about SMART Project Planning:

5. The project plan and charter should be treated as same set of documents or they will become disconnected.
6. A simple summary of planned, actual and expected end states for schedule, budget, scope, key results, priorities and risks support keeping key elements aligned and integrated.
7. This summary's successful implementation requires fully integrated approach to project planning and delivery together with addressing the real issues that affect the success of the project.
8. For effective planning process all key stakeholders need to be involved.
9. The planning must be done the way things are done, not vice versa.
10. The project plan is a critical communication tool that serves two roles: helps managing stakeholder's expectations and keeps participants informed. (Hartman & Ashrafi 2004)

2.2 Estimating and scheduling

Projects require money, resources and time. The precise amount needed is known only in the end of the project but with different estimating techniques it is possible to predict costs, resources and durations beforehand. These estimations are required for strategy planning, capital budgeting, project budgeting, project scheduling and project control. The degree of certainty varies between estimates and usually estimating is done several times during a project. The new estimation should provide better accuracy and confidence than the one before. Formed estimations should show effort per resource type and not just overall effort. (Gardiner 2005; Wallace 2016)

2.2.1 Activities in project schedule

An activity or *task* is a logical piece of work lasting a finite *duration* of time. Once the activity is completed, it results a deliverable or deliverables. Hence a *deliverable* is the output of an activity or task. It is easy to tell the state of progress on an activity when the deliverables exist. It means that the activity is finished but if the deliverables do not yet exist, there is usually much more uncertainty in the progress estimation. (Nokes et al. 2003)

There are usually four different relationships that can be indicated between two activities A and B:

11. **Finish-to-start (FS):** Activity A must be finished before activity B can be started. A time lag can be addressed with this relationship to indicate that there must be a delay before starting activity B or if the lag is negative, that B can be started earlier than A is completely finished.
12. **Start-to-start (SS):** Once activity A has started, activity B can also start. With this relationship a time lag can also be addressed to indicate that activity B can start only after a delay from A's start.
13. **Finish-to-finish (FF):** Activity A must be finished before activity B can be finished. In this relationship the time lag means the delay before B can be finished after A.
14. **Start-to-finish (SF):** If activity A has been started, activity B can be finished. A time lag can be used once again to indicate the delay before B can be finished after A has started. (Gardiner 2005)

The accuracy of activity's time duration depends on knowledge from previous projects. This is why data should be collected all the time from ongoing projects. If a comparable activity has been performed in previous project, the new activity's duration can be accurately estimated. However, activities with new scope of work may have a range of possible durations because they are difficult to predict. Durations can be fixed or variable. Fixed duration means that the activity will take a fixed length of time to complete from start to finish despite the level of effort. On the contrary, variable durations can change according to the level of effort. (Burke 1995; Nokes et al. 2003)

When several people are assigned to work on a same activity together, everyone must spend time negotiating with their colleagues on the same activity. This means that less activity-related work is being done and as the number of people rises they will have to spend even more time negotiating. Therefore, the need for co-ordination and communication means that additional persons added to an activity may not increase the effort with one person but actually a little less and besides it degrades the effort of those already working on the activity. This is also one reason why it is important to plan projects. Everyone should know the exact scope of their own tasks and multiperson activities kept to minimum. (Nokes et al. 2003)

2.2.2 Activity network

Project's activity network is created by defining logical relationships between the activities. Some activities are independent and some dependent on each other. Independent activities can be done at the same time and thus should be sequenced in parallel. Activities that are dependent on each other must follow one after the other and should be sequenced in series. At this point no resources are taken into account and the network reflects only the logical relationships of the activities. This means for example that activities are not placed in series just because the planner knows or thinks there is not enough manpower to do these in parallel. Resources are considered in the scheduling process and will affect the timing of activities but not the network logic. (Gardiner 2005)

When creating a network one of the most challenging parts is defining the activity relationships correctly. If the project's scope of work is new this process should involve several members of the project organization and consist of team work and experimentation of arranging the activities. On the other hand, if the new project's scope of work is already familiar, the company might have a ready frame for the project. This kind of knowledge about the previous projects is precious for the company. (Gardiner 2005)

2.2.3 Work breakdown structure

A task becomes a project when it is too large to be a single activity. For easier and better understanding of the project and the scope of work the project is divided into smaller steps. To do this the project needs to be defined fully and for that all of the project's deliverables and activities need to be known. Deliverables mean products and services that a project is going to provide and activities are any units of work that will result in deliverables. Activities should be named in relation to their deliverable for everyone to understand the meaning. The documentation defining a project scope needs to be done carefully to make sure that everyone will work with the same information and that they are committed to achieve the same end deliverables throughout the entire project. It is usual that the scope of project changes during the project so the documentation is very important. (Pinto 2010; Gardiner 2005)

According to Pinto (2010 p. 161), "a work breakdown structure (WBS) is a deliverable-oriented grouping of project elements which organizes and defines the total scope of the project." It is an easy way to start project planning. The WBS consists of many levels creating a hierarchy. The details of a project step's definition increases as the WBS level decreases. This process of breaking down activities into lower levels of sub-activities can continue indefinitely and it is hence important to think how many details are actually useful to manage the project. So instead of just a start date and an end goal, WBS gives checkpoints between the start and the end and a clear and logical way to inspect the project either on very detailed level or in a more broad perspective. (Pinto 2010; Gardiner 2005; Nokes et al. 2003)

The work breakdown structure serves these six purposes:

1. **Echoes project objectives:** WBS identifies the activities that need to be done to finish the project and accomplish the set goals. What gets mentioned in the WBS, gets done on the project.
2. **Is the organization chart for the project:** Organization chart provides a way to understand the project's structure, identifying the key elements that need attention and the logical flow from activity to activity.
3. **Creates the logic for tracking costs, schedule, and performance specifications for each element in the project:** All activities in the WBS can be assigned their own budgets and performance expectations. This is the basis for comprehensive method for project control.
4. **May be used to communicate project status:** With activities and responsibilities divided and goals set it is possible to determine which tasks are on track, pending or critical and who is responsible for their status.
5. **May be used to improve overall project communication:** In addition to breaking the project down to identifiable pieces, the WBS show how these pieces fit together in the overall scheme of development. With WBS the team members can understand how their part fits in the project, who is responsible of the upstream work and how their work will affect the later activities. This motivates team members to communicate and make activity transitions as smooth as possible.
6. **Demonstrates how the project will be controlled:** The project's general structure demonstrates the key focus that project control will take on. The WBS gives logic to the control approach and the most appropriate control methods. (Pinto 2010)

2.2.4 Project schedule

Scheduling means sequencing project activities and milestones into a sensible and logical order to aid project execution and control. This means linking activities to each other and forming a network with activity chains showing how they are related to each other. To find the expected project duration and milestone dates, the project schedule needs to establish timing of activities and resource requirements. During the scheduling process, commitment, consensus and feedback from stakeholders are needed. (Gardiner 2005)

Crucial for project scheduling are good estimates of activity durations which support outputs of the scheduling process. These are for example estimated project duration, critical path and project/schedule baseline. Mutual agreement about the time estimates is required for all the activities in the project. For estimating activity durations there are three different methods:

1. *Using data from previous projects*. Knowledge and experience from past is a good way to predict future events. The more data available, the easier and more accurate it is to predict durations for current project.
2. *Timing the activities*. If there is not any previous experience or data available, it may be possible to perform a trial run of an activity and use the results for estimating. This method requires relatively simple activities and in the estimates

learning curve should be considered if the same activity is repeated several times during the project. The last time the activity is performed probably takes less time than the first time.

3. *Using a probabilistic method*. If no historical data is available and an activity can't be easily tested, a probability simulation technique and/or an expert's judgement can be used. One frequently used probabilistic method is the weighted average technique which is suitable when significant uncertainty exists. It is based on three estimates of the activity's duration (usually made by an expert): most optimistic, most likely and most pessimistic. (Gardiner 2005)

The chain of dependent activities gives the first indication of how long the project will take. Usually after all activities are linked with correct relationships, the project will have several chains or sequences that come together at the end of each phase. These chains run partly parallel to each other and some have longer durations than others. Hence most activity chain branches will have some flexibility in timing but one of the branches defines the shortest possible duration of the overall project. This particular activity chain is the critical path and the activities on this chain are often in the focus of project management as any extension in these activities will move the project's finish date further. (Nokes et al. 2003)

2.3 Project control

Often when projects run late, exceed budget or fail to deliver customer requirements the reasons for these build up gradually in small amounts of money spent and days lost. To detect these problems and avoid them a control system is needed. Tracking and monitoring the project is also a way to assure the objectives and strategy are being achieved. With project control it is possible to gain understanding of the project and to facilitate decision making. Moreover, failing to deliver a task is not the worst thing to happen but having problems and hiding them is. To overcome problems they need to be reported as soon as possible to give enough warning time. It takes time to solve problems and most problems have several ways to solve them. However, there are hardly any ways to solve problems instantly. Consequently a lot of the project control work is done to maximize the warning period and to avoid problems. (Lientz & Rea 1995; Maylor 2010; Nokes et al. 2003)

Hartman & Ashrafi (2004) have collected information from projects to determine what is important for project success, what is measured during the project and what project drivers were over the various phases of projects. Here are summarized some key findings from their study:

- The importance of critical success factors, metrics and project drivers changes over the phases of a project. It is important to understand what is important at various project phases. For example what type of management style is suitable at a particular phase, who should be involved, when, and to what extent. Moreover, how to communicate with whom and when.

- There were differencies in what is regarded as important, and what is measured during the project. This means that wrong things are often measured during the project.
- In order to manage projects effectively, an understanding of how changing project priorities during various project phases affect the planning and managing.
- Risk identification is more and more common but risk management is relatively rare. (Hartman & Ashrafi 2004)

Important part of controlling the project is information collection. Often in projects there is so much happening it is difficult to monitor everything and to decide what to monitor. Therefore a summary of project status highlighting tasks that need attention is needed (Nokes et al. 2003). Further, an effort should be made to have a unified and integrated approach to data collection to avoid asking the same person different inputs several times and making the reporting lighter. This saves time and the team members who are reporting may not feel it so arduous. Maylor (2010) points out that whatever data is collected it must be reliable. People tend to give too positive estimations on progress often. Thus, people need to be clear what information to report and in what format and they require feedback about their performance. (Lientz & Rea 1995; Maylor 2010; Nokes et al. 2003)

Even the best plans and schedules are not useful if they are not up to date. It is not enough to ensure that everyone involved in the project understands the plan in the beginning as circumstances will change, new information will emerge and people may not remember all the tasks and objectives. Therefore, the project schedule should be updated to reflect what is actually happening and to keep the project on track in the real world together with the schedule and plan should be referred to constantly. Consequently, keeping the project running smoothly involves gathering information about progress and taking actions to keep the plan and reality in line. (Nokes et al. 2003)

Maylor (2010) discusses about principles of control which require that measures can be obtained for the progress of projects. The issue with assessing percentage of completion for a particular activity is often more art than science. Likewise, the information may not be real-time. The kind of optimism bias mentioned earlier, when people tend to give too good estimations, makes the progress assessment unreliable and challenging. The data collection for progress and schedule updates can be done in many ways. The most common ways are electronic methods like email, project specific website and tools, placing data onto a shared server or collaboration tool and using a project support toolset operating through a network but also face to face meetings and traditional paper reports are used sometimes. There are many automated project support tools to help in reporting but whether or not this kind is used there should be a well-defined process and formats in which the information is captured. Furthermore, it is important to ponder whose input is needed i.e. who need to submit information in order for effective project control. Sometimes persons with highly valuable input are not in direct control of project manager which can become an issue if the information gathering is challenging and

the person with information is busy and not interested in extra reporting. (Maylor 2010; Wallace 2016)

When measurements of time and cost are made and progress trackers are used, a baseline to compare against is required. Though, the comparison may not always be reasonable as the particular part being compared might have been simply a guess at the time it was planned to fill a gap in the plan. The intrinsic uncertainties in the estimates mean that the controlling activities may require modifying the pace of work and allocated resources together with reviewing the baseline. Once the schedule is updated and possible issues have risen, the focus should be on these problems. Limited progress usually means either little work done or increased problems. Moreover, it is important to make sure that all of the project team is aware of all the current issues and their status. An open process is superior to a closely held approach where there is minimal communications. (Lientz & Rea 1995; Maylor 2010)

2.4 Project organization

Managing projects means managing people. One task for the project management is to gather together a group of individuals and try to make them a cohesive whole to ensure benefit for all stakeholders. Project teams are often formed from multiple organizations and geographically separate locations. This brings extra challenges to the project management. The entity of project organization is important as it:

- defines responsibility and authority
- outlines reporting arrangements
- determines the management overhead (costs)
- sets the structure behind the organizational culture
- determines one group of stakeholders in project activities. (Maylor 2010; Nokes et al. 2003)

Project organizations have different roles and they might have different names within organizations but the responsibilities are usually same. The following split of roles and responsibilities has been found to be most efficient for organizations with many projects at the same time. The project roles are sponsor, project manager, team member, programme board, project support office, stakeholders, specialist advisors, external suppliers and end-users or end-user representative. As the project team will work together toward the achievement of a common goal, few things should be kept in mind:

- Some people’s tasks will require milestones or end products from the tasks of other people on the team.
- The team will share common methods and tools (e.g. The project schedule)
- The team will have to identify and solve issues together and face the results.
- The project will success or fail depending on the final end product. If one person blunders, the team suffers.

The interdependence and accountability for the final result makes the team's success everyone's self-interest. (Nokes et al. 2003; Lientz & Rea 1995)

2.4.1 Project organization structures

Project-based organization structure is the most common in construction industry. In this structure at the highest levels in the organization are project boards that include senior managers, directors and administrative staff etc. seen in Figure 7. The next level covers project managers who have control of one or more projects at a time. The structure of the project team depends on the stage of the project lifecycle. At the planning phase there will be engineers, architects and other technical specialists who are then replaced at the operational phase by various contractors that carry out specific tasks. After the project is completed the project team is disbanded and the project manager is usually retained to move on to other projects. (Maylor 2010)

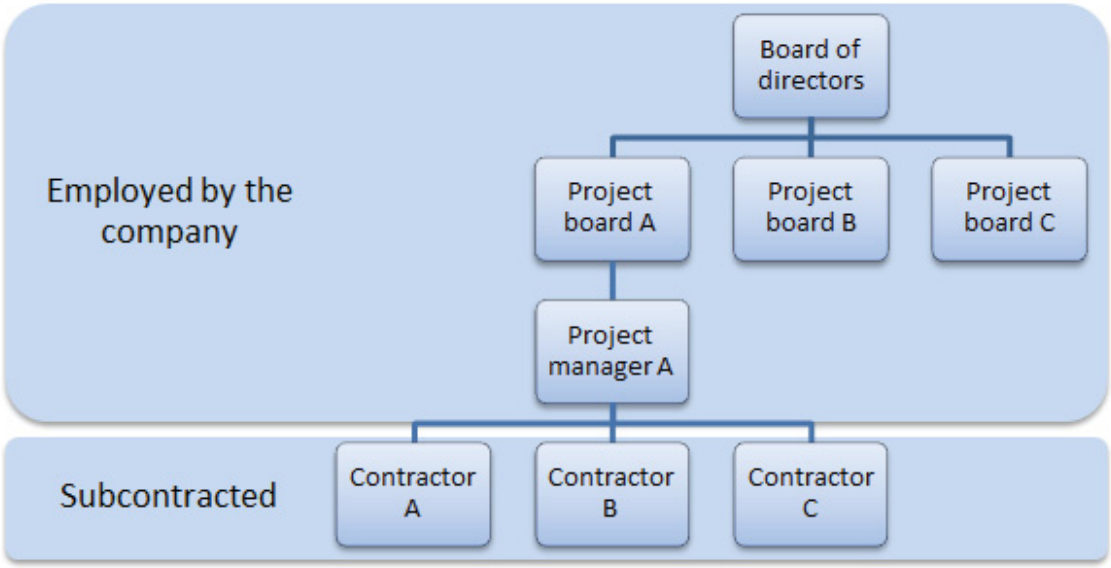

Figure 7. *Project-based organization to paraphrase Maylor (2010)*

The advantages of project-based organization are highly flexible labor force and saving on the costs of directly employing by using contractors. However, the disadvantages are significant. As the project team is only temporary people might have no commitment to its success and paying on a time rate encourages to drag out jobs over a longer period. In addition, the knowledge about the executed project does not pass on to future projects if the same people are not part of the new project team and work methods improving is likely to be slower. Moreover, certain industry booms make hiring problematic as there is a shortage of labor and the labor rates increase. (Maylor 2010)

Matrix organization is an alternative structure which has some of the project organization's benefits without the disadvantages. Matrix management suits best in these three situations:

- There is a need to share resources between functions or projects.
- There is more than one orientation to the activities of the operation, e.g. multiple customers or geographical differences in markets served.
- There is a need to process simultaneously large amounts of information.

In matrix structure, as seen in Figure 8, various members of both resource type teams and people working on processes or functional teams will need to work together and share knowledge. All of these sub-teams horizontally and vertically need a leader and the team members need to understand their individual roles. This creates a challenge for reporting and controlling responsibilities. Matrix organization structures require acceptance of the system by the people who are working within it and ability to work with overlapping boundaries. There are three different models for matrix organization. In *a lightweight matrix* the project manager acts as a coordinator and calls meetings of all the departments involved. Responsibility of success is shared between the departments. In this structure the project manager is relatively powerless compared to functional managers. *A balanced model* tries to balance the power of the project manager and line manager. The administration of the organization is such that the line manager needs the activities of the project manager to balance their resources. Team members in this structure will have both project and line responsibilities and the disadvantage of this model is crossing commands from the project and the line manager to team members. In *a heavyweight matrix* functional departments provide people on a full-time basis to the project team and after the project is completed they return to the line function. This arrangement is useful if the project is of vital importance to the organization. The discontinuity of tasks for individuals and functional departments is a disadvantage of this model. (Maylor 2010; Wallace 2016)

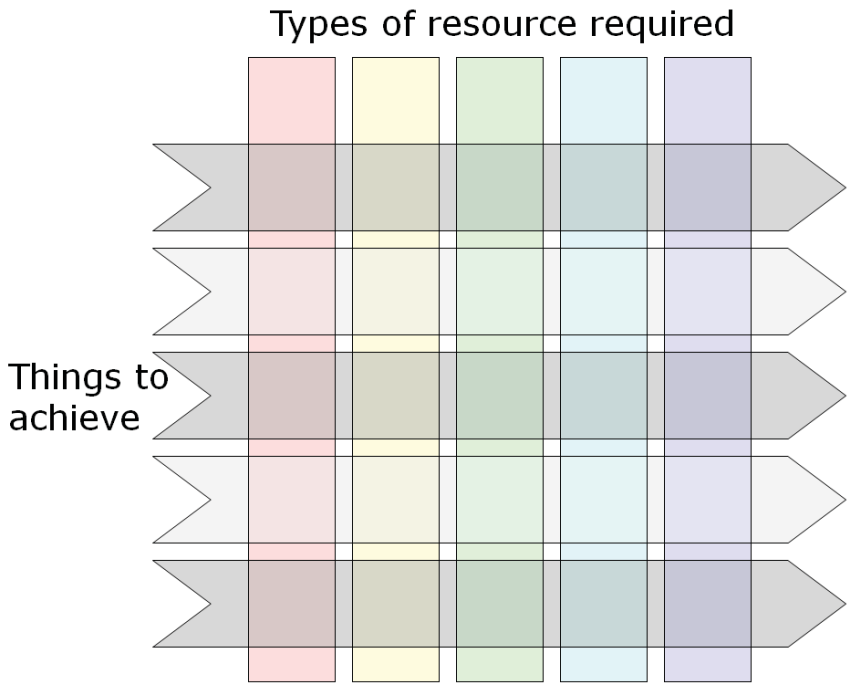

Figure 8. *Matrix structure for project organization (Wallace 2016)*

When selecting the best structure for a project the following things should be considered. Taking in account the predominant technology of the firm and potential resource conflicts. Therefore, the decision should not be taken in isolation. This highlights the importance for an organization of the aggregate project plan and the project being given a definable priority. It is not useful to have a heavyweight matrix structure for all the projects in a company. Usually the projects with highest priority level should have the heaviest weight structures. (Maylor 2010)

Moreover, people in the same team and working together generate collaboration, knowledge sharing and skills transfer. Besides, teammates usually help each other to achieve their collective goals. Though it should be noted that the team structure will influence the way a team behaves. Therefore building effective team is vital. (Wallace 2016)

2.5 Internal customer relationship and communication

Clarke (1999) has identified communication throughout the project as one of four critical factors to project success. The importance of communication in organizations is well known, especially its influence on the acceptance of anything new. However, it is also considered to be one of the most neglected parts of organization's operations. The first step to achieving more effective communication within an organization is to have a better understanding about the benefits and limitations of each of the main communication methods. Successful communication needs to be focused rather than broad-brush. Tim-

ing is also of great importance. Properly used, communication can have many benefits such as:

- Reducing non-productive effort
- Avoiding duplication
- Helping eliminating mistakes
- Helping managing uncertainty
- Identifying problems sooner
- Generating ideas that lead to better solutions
- Encouraging team work
- Increasing motivation
- Ensuring the involvement of all key players (Clarke 1999)

One of the best ways to motivate people and make them more confident is through effective communication. This can be achieved by adopting a focused communication strategy and using a variety of methods to communicate. When people become more aware of what is happening in their organization and are better informed, they will become more involved and committed and thus better motivated. Leading by example is one of the most successful ways of communication for motivating people. As managers and directors within the organization use project management practices and methodologies, these ways of working will become more easily accepted across the organization. Hence, this behavior is accepted as the norm. (Clarke 1999)

The project management methodology is often considered as a company reporting tool rather than a useful system that different departments in the organization can use to help them. There is usually only little or no feedback at all from headquarters to sites. Information flows to both ways need to be improved with a better sharing of information between the sites and from headquarters to sites. Whereas there is a need to maintain confidentiality of some information at a strategic level, much of it could be distributed to a wider audience. Clarke (1999) notes, that making information available to everyone in an organization produces more motivation and a better informed work force. (Clarke 1999)

Organizations have internal service functions that support each other and also external service functions. If internal service is not good, external service suffers. Usually people have difficulties to understand the importance of their work performance in internal service functions. They rarely see external customers and easily experience that they are only serving co-workers and that their service do not affect the external work input in any way. One way to handle this attitude problem is to introduce the concept of *internal customer*. This concept brings customer relationship inside organization which can be seen in Figure 9. The eventual result from the service process is external service received and experienced by client. As the personnel realize the existence and significance of internal customer relationships, attitudes are much easier to change. The concept creates a new dimension for the operations performed inside the organization. The

personnel will realize that satisfied customer does not only imply to company's external individuals or organizations. (Grönroos 2000)

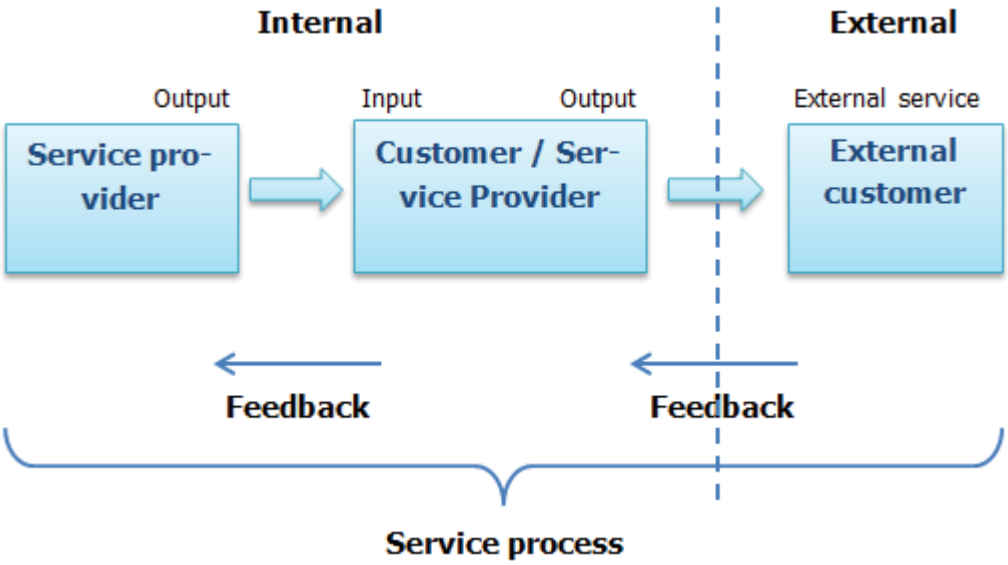

Figure 9. *Internal service functions and customers to paraphrase Grönroos (2000)*

The goals of internal communication can be divided roughly to three parts: flow of information, interaction and commitment. Internal communication provides that everyone gets the information they need for performing their own tasks or that the information is easy to find. One objective for the communication is also to affect that individuals comprise themselves and the meaning of their work as a part of their unit's and whole organization's ensemble. This is highlighted in the induction of new employees but it is only the beginning. The means of communication should be used to continually strive to affect that every member of the organization sees their own work in relation to the ensemble that is the tasks and objectives of the company. Another important objective is to create and maintain open interaction at company and hence boost we-spirit and will to work, together with encouraging people to develop the workplace and work. Part of the openness is that messages can pass without any impediment from management to subordinates, vice versa and horizontally between offices, departments, teams and individuals. According to Smith & Mounter (2005) lateral communication is perhaps the most difficult to fix between different units and functions with offices around the world. Moreover, part of openness is to be honest about causes and effects. (Kortetjärvi-Nurmi et al. 2008)

One internal communication's task is to support the vision, strategy and values of the company. This is particularly a part of management communication: reporting company's objectives, results together with future plans and scenarios and the changes these will cause. This means visualizing the chosen vision's, strategy's and values' meaning in everyday operations. It is important to deal with changes together with staff. Values given from management without thorough thinking and discussion will not change atti-

tudes and therefore everyday operations either. People need a chance to internalize company values and objectives of actions. Fulfilment of vision requires that people understand it, believe in it and want to execute it. Giving the information is not enough for commitment, the information also needs to be understood and acknowledged. (Kortetjärvi-Nurmi et al. 2008)

Not sharing information impairs the atmosphere of a workplace and decreases motivation to work. Thus the right information needs to be given as soon as possible so that an information gap is not formed. Nothing new to inform is also important to know. People will stay calmer when they know where things are going and if there is nothing to expect at the moment. In a time of changes the demand for information grows and thus communication and information sharing is needed more than normally. A change is easier to accept or at least to understand if background, causes and effects of the change are told. (Kortetjärvi-Nurmi et al. 2008)

Internal marketing is a management strategy and if senior management does not understand the strategic importance of it, the money spent on operations and processes of internal marketing will not pay off. In this case, also investments on technology and on systems will often go to waste. To be successful, internal marketing needs active and continuous support from senior management that occurs as actions along speeches. Focus in internal marketing is on good relationships between all level employees to create customer-oriented mindset. Besides the right mindset, skills and support systems are needed. (Grönroos 2000)

Internal communication is affected by computers as they work as a platform for communication. Smith & Mounter (2005) uses a term computer-mediated communication (CMC) which includes intranet, group networks and websites. CMC has become a big part of communication but individuals still prefer face-to-face communication and direct human contact. ‘High touch’ rather than ‘high tech’ is what is needed. Phillips (2001) also warns about the chance of secret information going outside the organization when using CMC.

2.5.1 Knowledge management

Understanding of a situation for a decision maker of organization is based on the knowledge he or she has in hand and which he or she interprets through their personal earlier experience. Relevant and timely information can help organization to recognize and analyze alternative solutions in decision making situation. With the help of knowledge different settlement options’ good and bad sides can be evaluated and compared, available offers can be trimmed and eventually the best option can be chosen according to the current understanding. Knowledge based and justified decisions steer company’s operations to better direction and help the company to succeed compared to its competitors. Information is not automatically valuable or creates advantage in com-

petition. It might be even more harmful than useful to organization if quantity is emphasized instead of quality and usability. In worst case, the result may be an information overload which cripples the operations as the amount of information in the system exceeds the processing capability. The amount of available data and information has grown as a result from technological development, faster communication links and globalization. In addition, more varying information is available due to growing usage of social media among other things. As huge amount of information is available, it is important that it can be controlled by parsing and sorting the mass of data. The information valuable to organization is relevant to its user with its contents and it is with right person, at right time and in usable form. In order to create value, information must be interpreted properly and it must have influence on decision making that steers the functioning of organization. (Laihonen et al. 2013)

Today data, information and knowledge play a big part in companies and managing it has become important for organizations. Knowledge management (KM) promotes the creation, capture, sharing and application of organization's knowledge (Becerra-Fernandez 2008). Laihonen et al. (2013) states that the competitiveness of a company is based on knowledge and expertise. It is about how well products and services that customer appreciates can be made. In addition Becerra-Fernandez (2008) argues that collective knowledge of organization's employees, customers and vendors is the most vital resource of today's enterprise. Over the years companies have faced challenges organizing and making available important knowledge but with learning to manage the organizational knowledge this can be controlled. In addition to other benefits KM may improve decision-making, strengthen organizational commitment and build sustainable competitive advantage (Becerra-Fernandez 2008).

According to Maier (2007) companies are moving towards the ideal of a knowledge organization where individual knowledge workers form an intelligent and adaptive system. Together they are capable of combining knowledge rapidly from within or outside the organization to solve problems and hence create value to the company as well as flexibly adapt to environmental changes. Highly knowledge-intensive organizations depend heavily on the expertise of their employees and the networks between them. As knowledge workers are specialized they usually need to work in groups and teams that differ in social structure and interactions. To bring people with special knowledge together and to provide a smooth connection the organization needs a frame. Organizational advantage means offering an environment for joint knowledge creation and application. Virtual teams, expert networks, best practice groups and communities supplement traditional organizational forms like work groups and project teams and support collaboration across organizations. (Maier 2007)

Knowledge management has three perspectives, understanding the phenomenon, practices of management and management tools. The first one means understanding how knowledge is used to create value in business processes. When the value creation for

shareholders is understood it is possible to identify, develop and manage important information resources. With the third perspective the focus is on the tools that are needed to get a better hold of immaterial information processes and how to make use of the new instruments that information and communication technology has enabled. In organization knowledge management is visible in two ways. It is part of every knowledge worker's professional competence and conceptual tool box. Every individual needs to master for example practices for information sharing and instruments supporting it. Although there is also knowledge management tasks that are carried out by analysts specialized at mastering business information in companies together with other experts. (Laihonen et al. 2013)

According to knowledge-based view knowledge is in people and the mission for organization's management is to coordinate processes that are used to integrate products and services from knowledge. Knowledge management is also used to create value to internal customers. With effective utilization of knowledge, decision making can be supported or work that does not add value can be reduced. Knowledge management consists of many sub processes with which knowledge is created, collected, shared, processed and distributed as seen in Figure 10. To each of these processes are associated with several practices that vary between industry, size of organization and strategy selected by the organization. On the one hand focus is more on people and tacit knowledge, on the other hand focus is on explicit knowledge and information systems. Naturally it is rare to have only either of these extremities as an operating model. It should be kept in mind on a practical level that successful knowledge management is often sharing, adapting and creating knowledge supporting circumstances' and practices' creation together with systematic use of knowledge. When available knowledge is utilized and decisions are based on truthful understanding of a situation, knowledge creates value. The understanding of a situation consists of knowledge gathered inside and outside the organization. In addition to knowledge from information systems, also human knowledge and expertise is needed. Explicit measurement information produced by key figures is often associated with the understanding of a situation. It can be used to help decision making and to improve actors' awareness of the prevailing market conditions or the efficiency of operations. (Laihonen et al. 2013)

Figure 10. *Knowledge management process to paraphrase Laihonen et al. (2013)*

Knowledge management is not a separate management function but it has become a natural part of the prevailing management style and course of action. No one is taking care of it for others but everyone is taking part of it with their own actions. Knowledge management can be seen as a management paradigm of knowledge-intensive organization. Consequently there is not a separate "management process of knowledge work". Instead there is conventional management where it is noted in practices that the target is knowledge-intensive work which is performed by autonomic and creative experts. Therefore knowledge management is a fixed part of knowledge-intensive organization's general management practices. Experts need freedom to design and implement their own working methods, time and the most suitable place to work creatively and effectively. However, this requires setting clear objectives for working. Additionally, common and shared objectives are needed in workplace to make collaboration between individuals possible and effective. (Laihonen et al. 2013)

Knowledge management is especially present in the weekly Lean meetings introduced in chapter 2.1.1 where coordination, socialization, establishing commitment, knowledge transfer and learning take place. The Socialization-Externalization-Combination-Internalization –process abbreviated the SECI process created by Nonaka & Takeuchi (1995) shows how the meetings act as learning arenas. The four terms are states of knowledge conversion that occur on configurations of tacit and explicit knowledge seen in Figure 11.

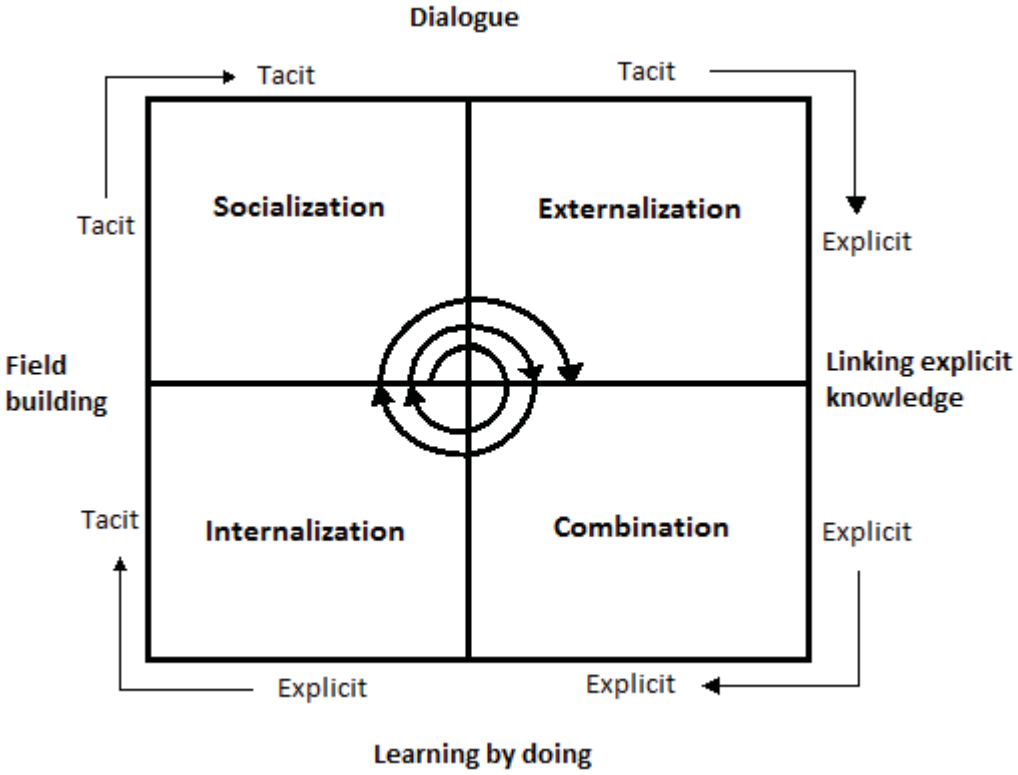

Figure 11. *The SECI process derived from Nonaka & Takeuchi (1995)*

The SECI process starts from the state of socialization. In this case, this means the weekly Lean meetings where people with tacit knowledge meet and share experiences. Next is the externalization state where tacit knowledge is converted to explicit knowledge thus making the knowledge available for the rest of the project organization. Due to intractable transfer of tacit knowledge, many ways to convert knowledge at this state are used such as metaphors, analogues, storytelling and hypotheses. Once the knowledge is explicit, it can be integrated with other explicit knowledge for gaining new deep knowledge. This is the combination state. Finally, the new explicit knowledge is added to current tacit knowledge of individuals in the state of internalization. (Emblemsvåg 2014b)

The explicit knowledge is quite simple to manage but according to Cavusgil et al. (2003) tacit knowledge embodies the true competitive advantage for companies. This is due to that tacit knowledge is difficult to transfer or interpret for other companies. The SECI process is relevant for project planning as the planning system must obtain information also from tacit knowledge of the project organization. When planning is conceived to base on facts transmitted with different expressions, it means that communication must be one of the primary functions of planning. (Emblemsvåg 2014b)

3. CURRENT STATE OF PLANNING

This chapter portrays the current project planning process at the target company. It involves different departments and individuals with many interfaces. The only one working with the plan from the beginning until the finish is the project planner, thus making him or her, the most important individual for the project schedule and plan. Between the first schedule creation and finishing the project, several people will participate in the process. Consequently, this chapter is created by interviewing employees at different positions and departments at the target company. In addition, a process overview of target company's sales-order-delivery-process is used to demonstrate the planning process.

The data collection in interviews was performed with only few directive and supportive questions to begin with. For this data several people were interviewed from project management, engineering, production and procurement departments. The interviewees described their own parts in the process and what kind of challenges they had detected. Moreover, they were asked for development ideas to the occurring issues. The current state of planning in target company is analysed with this survey.

3.1 Current state and challenges of departments

The project sizes of target company has grown significantly recently. Earlier projects consisted of modernizing and building of accommodation and food handling areas in maritime industry but new projects cover whole living quarters including steel works, background outfitting with piping, ducting and cabling to mention and interior outfitting together with testing and commissioning. Compared to previous, the number of subcontractors and suppliers has grown vastly and thus the need of controlling these. In contrast, the project planning and control have not changed much. One project planner has responsibility over few projects at the same time, though most of them are small projects at the moment. The level of details and measuring in project control is relatively same as earlier or little higher but there are no standardized tools or ways for measuring key performance indicators (KPI) yet. Current project management software, Primavera P6, is capable for handling big projects and is in this way up to date with grown project sizes. The usage may not be as effective as could be and potential for more efficient utilization can be seen. However, this requires investments in form of labour and possibly more licenses and add-ons.

The project planning process seen in Figure 12 starts at sales phase where first scarce schedule version is created for quotation. In this stage only little input or none at all is

needed from other departments and the schedule is created with the knowledge and experience of project planner and salesperson. The schedule contains only few key milestones like project start and finish dates together with engineering, procurement and construction time lines. Any specific tasks are not defined at this phase. Next, the schedule is modified for fixed quotation. It is specified with input from different departments (if possible) according to current scope. Few tasks are added to the schedule under the disciplines and these durations are estimated.

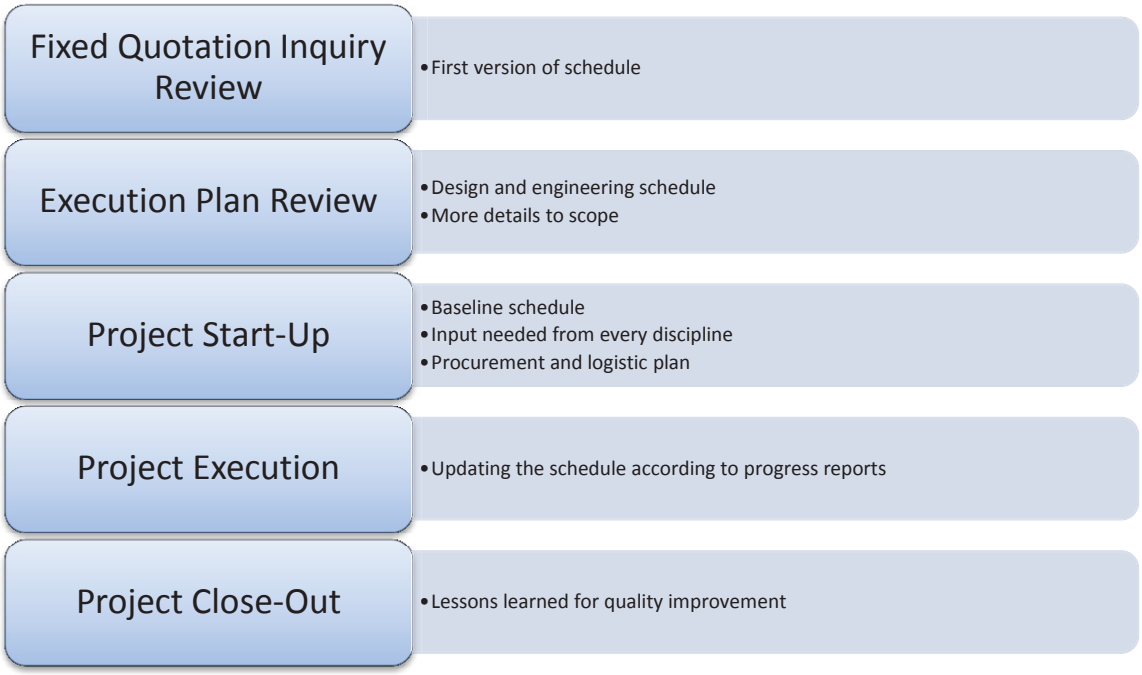

Figure 12. *Project planning process with focus on schedule*

Once the contract has been awarded, a more specified and detailed schedule is being built. More activities and possibly more accurate durations are added. For these an input from each department is needed. Also project baseline is created at this stage and activities will get weightages for progress measuring and resources are divided with available knowledge.

Once the project has started, weekly reporting will be made with progress updates and forecasts to the client. These include s-curves from various disciplines and overall performance together with the project schedule normally as a Gantt chart. The project schedule is exported from Primavera P6 and the s-curves are sent from BI Publisher. However, these s-curves are not satisfactory for all shareholders as P6 allocates progress with average values meaning that a small part of weekly progress often goes to past weeks. This changes the curve for previous weeks a little which usually raises questions as it is not logical. Thus, a separate Excel sheet is sometimes used to manually draw the s-curves. Consequently, this means extra effort for the project planner.

After the project start-up, the project schedule is updated when needed and when new information is received. The updating of activities with P6 and demanding clients is arduous and hence the updates are normally kept in minimum. As many updates as possible are done together to save time as the project planners are busy with responsibilities over multiple projects.

At project close-out, a list of lessons learned is collected to avoid the same mistakes in future projects but also to note what went well.

3.1.1 Project management

Project management is responsible for finishing the project in time and hence the project schedule is important. At the moment the schedules have good frames and the baseline schedules are done very well. However, more effort is needed to better reflect the reality in activities as the project proceeds. In practice this means more accurate updating more often. The usage of project schedule has been mainly in reporting status to customers and to present project's progress which is used as basis for billing. In addition, project management needs the schedule for controlling and monitoring progress and managing changes, risks and mitigation plans. This means that the schedule should be reliable (for example deadlines and milestones) and it requires internal transparency so that everyone in the project organization could and would use the schedule. The management should be able to forecast and react to critical activities early enough and try to keep the costs in minimum.

Currently challenges with the project schedule are activities' accuracy to reality and their linking to create an activity chain which would be reliable and could be used in forecasting. Moreover, continuous updating of these is needed. One issue is also dividing resources and weighting units, which will generate progress, for activities. From managerial perspective, more details are needed for procurement and construction activities in the schedule but engineering is currently fine. Overall the projects should be more planning driven. Project manager's experience and knowledge about the product is having too big role at the moment. Like mentioned, projects' sizes have grown at target company and project manager's experience and skills are not enough anymore to control the whole project effectively. The manager needs a reliable project schedule to help him and others in the project.

There are also a number of issues from project planner point of view. The current project planning system, Primavera P6, and its features are sometimes challenging. The system lacks in lighter schedule versions that are needed for different disciplines and departments. Also exporting reports from P6 and Publisher is arduous and could be more automated. As a result of this a lot of work and documents are done with Microsoft Excel which means extra work and lack of standardization in reporting. In fact the lack of standardized operating model for project planning overall is one of the chal-

lenges. This is difficult as the projects differ from each other (full turnkey vs. visual turnkey projects) and clients usually have special requirements or at least not similar requirements with other clients. An issue that results in incongruent functioning between departments is the dividing of scope. The project scope is defined and divided differently in engineering, procurement and in Cost Calculation Sheet (CCS) for example. Moreover, the project schedule's WBS which divides the scope differs from the others. This weakens the communication in planning process and makes progress reporting to P6 difficult as there are different names and allocations for tasks. This is one reason for why the project schedule is not used as much as hoped and the progress updates feel irrelevant as the information from the schedule is not useful when people have different tasks in their own departments. If the scope division would be same at each place, also the progress reports to the planning system would be easier and more meaningful. Furthermore, a challenge for project planning in target company is the planning of key subcontractors as they are a crucial input for the overall plans. The target company does not operate on the same shipyard or have own production so it has to rely on the plans and schedules from subcontractors. To make things a little more complicated these plans and schedules are not usually available at the time when initial planning takes place at target company. Thus, uncertainty plays a big role in the beginning.

From planning perspective there are also separate challenges for different departments. Engineering activities are challenging to divide and sequence with other departments. Activity durations and activities' effect on the chain are difficult to estimate and using only the list of documentation in the project schedule is not giving good forecasts. Procurement tasks have a lot of suppliers which makes the dividing of tasks even more complicated. During the building of baseline schedule a little is known about suppliers and their lead times for materials. A question has also risen if procurement activities should have weightings or not. Another issue is the contrary of details. Scarce activities are easy to manage but have little value in forecasting and detailed activities might give good forecasts but are extremely difficult to manage and there are already difficulties to update procurement activities at the target company. Moreover, reasonable and categorized information about materials are needed to adjust the schedule if there are effects on the installation timing like the need of hauling large items or fixed installing.

Production planning needs more input from supervisors. The sequencing of activities is challenging without the knowledge from those who will execute the tasks. There is also uncertainty about the level of details in production activities and estimations on resources. An important input for planning system is the estimation of remaining work which has been difficult to get. In contrast, production department wishes more detailed and clear activities which would mean more activities in the schedule and more reporting for the supervisors that are already having trouble to provide all necessary information to the progress reports.

3.1.2 Engineering

Engineering department gets their scope of work in quotation phase and it contains the documentation list they need to produce. This is sometimes used for the schedule as well in form of deliverable defined activities. It gives a good look of what will be produced but is difficult to sequence with procurement and installation activities.

The project schedule is important for engineering. Designers need to know when their part of the work has to be finished and how it is affecting others' work in the project. At the moment there are several challenges with the schedule. One of the biggest problems is creating the schedule in a correct way so it meets the needs of engineering. Currently it is created in an "as early as possible" –manner but it should be created from the basis of production to avoid extra work due to changes in design. In addition, the structure should match up to reality and not to assumptions. There are difficulties with tracking progress because of limited data in the beginning of a project when the schedule is created. Also the control of changes is difficult in the schedule.

A big challenge is the linking and more accurate definition of the activities in the schedule. This is needed for the activity effect chain and forecasting. The schedule should be able to show the critical paths and their meaning. With these everyone should be able to see few weeks ahead in the future and the understanding of everyone's work to others should be clearer. These things are hoped to be shown in project meetings by project planner or manager.

There is a demand for dividing the designed areas already in the engineering phase. Usually the same area is divided to multiple subcontractors who all need the same design documents for the area. This results to a hurry in the engineering department as they need the whole area design finished already as the first subcontractor starts working even though the last subcontractor and their part of the documentation would be needed months later. Thus, the number of mistakes in designing is often higher and more corrections and changes are needed later in production phase because all the details are not known so early in advance. In this case the costs of mistakes are significantly higher if the mistakes have been done in construction also. In other words, the engineering department needs to design areas of which they do not have full details yet, thus a partition and priorities for these design documents is needed.

3.1.3 Procurement

Procurement for project starts with a purchase request from engineering which gives information about the needed materials, items and labor. Using this information the purchasers will provide everything on site with the help of logistics department. The project schedule is needed for the suppliers to know when the materials are needed on site and to forecast if everything can be delivered on time. In reality the purchasers rely a lot

on the engineering schedule and they are mostly using information gained from there. At the moment the actual project schedule is not used a lot in procurement. A challenge for the schedule is the definition of items. Some activities are too scarce and it is not clear what they include. In addition, the schedule should be more compact. It is too broad and searching for information is too arduous.

The Product Shipment used to track deliveries is not clear enough and needs improvements. The item names are sometimes confusing and lack information about the size of items. Especially large items have effects on schedule which are important for planning. Because of the ambiguous item naming, progress updating is difficult and needs too much work that could be avoided. For example weekly progress reporting usually needs interviewing of purchaser to clarify what has been ordered and delivered because the information cannot be found from Product Shipment. Furthermore, there is also confusion between logistics coordinator and purchasers about the items in Product Shipment. Thus, logistics coordinator at site is not updating the arrived items often enough. This adds the unnecessary work as the planner needs to ask separately for updates on arrived items.

In procurement a clear critical path for the supplied materials and its presentation in project meetings would be needed. This would include separating all the critical items for each purchaser and making clear which activity will affect which activity in the schedule for better understanding of the whole project and every individuals meaning in it. At the moment the schedule and the showed critical path in meetings are too complex and disorganized. Some activity names are also ambiguous and better definitions are needed. A focused and compressed schedule with procurement related activities and a brief analysis are hoped.

3.1.4 Production

In production the project schedule is needed for work planning and subcontractor controlling. These include for example manning plans and estimating how many hours are left to use, dividing the working areas for subcontractors and scheduling the working periods for subcontractors (i.e. when they will start and finish).

The project schedule is not useful at the moment for site managers and supervisors of production as it is too complex and broad. In addition, activities in the schedule are not similar with the tasks in reality because they are not updated often enough. Controlling of subcontractors is based on the current feeling of site manager or supervisor and they do not get the help from project schedule. They do not have a tool which they could rely on and base their decisions and make those decisions align with other supervisors' decisions. More detailed schedule which could be focused on different disciplines or subcontractors of the project is hoped for the production.

More information and help from schedule is needed for making the manning plans. Supervisors need to know how many hours do they have in use and make decisions about needed labor to finish their disciplines in time. This way the supervisors could also forecast if they will need extra manning to finish and inform project manager about the rising labor costs earlier.

3.2 Main challenges

More effective project planning and scheduling are needed in the target company but several things need to be managed in order to do that. A cause/effect analysis portrayed in Figure 13 was used to find out the main challenges at project planning.

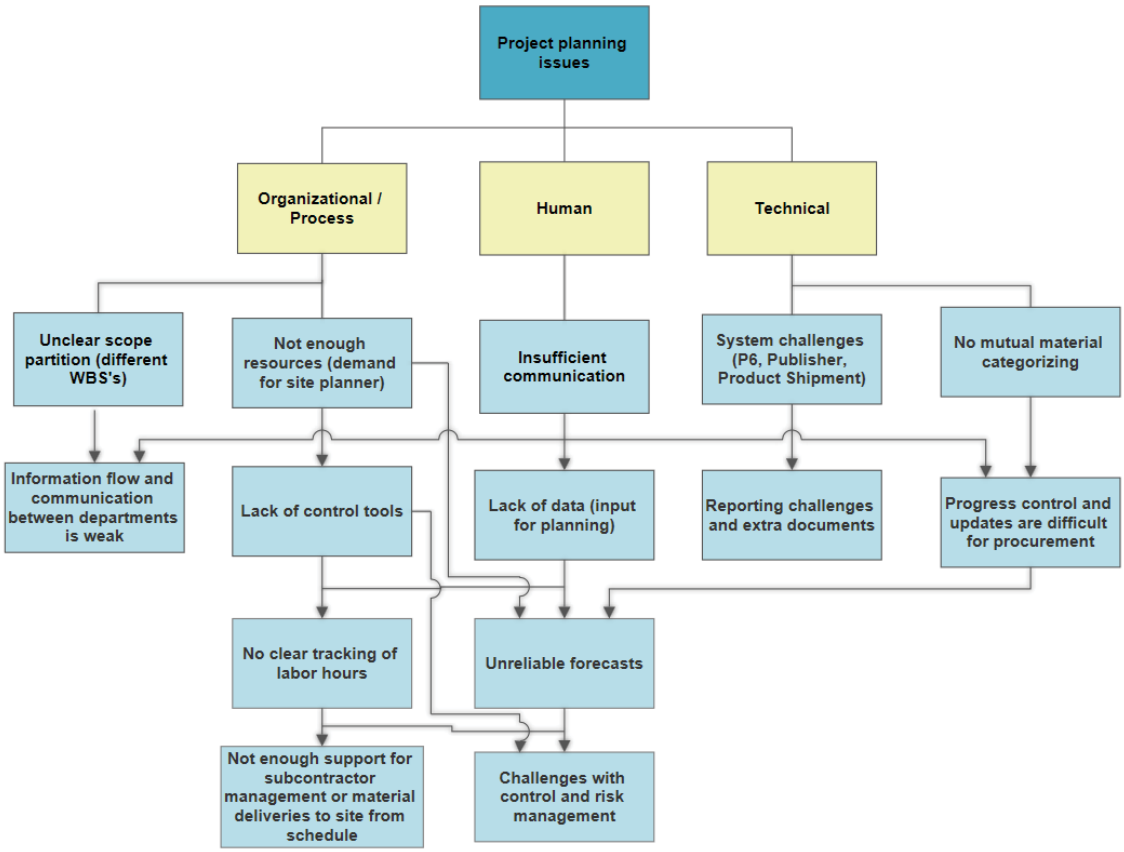

Figure 13. *Cause/effect analysis for project planning issues*

The challenges are divided to three categories: organizational/process, technical and human. The biggest challenges are caused by insufficient communication and lack of resources at planning department and these two are related to most issues. Only the most important ones of the lowest level issues are showed here. In addition to these, challenges such as subcontractor's quality of planning, were detected. These kinds of issues are difficult to solve or manage as they are outside the organization. Requirements for subcontractors' quality can be made but it is not a guarantee that the required level will be reached. Moreover, there are usually many other things to consider when selecting subcontractors other than the planning acquirements.

4. RESEARCH METHOD

This study has been carried out as a participatory action research. This qualitative research method integrates observing, documenting, analysing and interpreting characteristics, patterns, attributes and meanings of a phenomenon under study. In participatory action research, the research is done 'with' people instead of 'on' or 'for' people. In this research, the researcher is also part of the target company along with the interviewees and takes part in operations and daily activities at the target organization. The purpose of action research is to impart social change with a specific action or actions as the ultimate goal. In addition, it tries to change prevailing practices and to solve problems. Hence, this research is a way to take action to address problems and issues in the target organization with fostering collaboration among the researcher and the interviewees.

The interviewees were selected from related departments to present their point of view to project planning. These interviews can be considered as expert interviews since the focus is on their own work and the discussions are describing their working methods, challenges and development ideas. A total of nine people were interviewed which most of had lots of experience in their department and at the target company but there were also a few with less experience. This gives the perspective of younger employees who probably have not adopted all organizational attitudes and practices yet.

The interviews were semi structured with few open questions to lead the interview on right topics. Most of the interviews took approximately 45 to 60 minutes and they were recorded by taking notes during the discussion. Everyone was interviewed privately with only the interviewer and interviewee present. All the interviews took place during the end of winter and spring of 2017. After the interviews, the results were collected from the notes and they are presented in this study. The results from different departments are presented separately and these are analysed in detail in chapter 5.

5. OPPORTUNITIES AND ALTERNATIVE PRACTICES FOR PLANNING

This chapter presents the findings and outcomes of the research. They have been generated by analyzing the data from interviews and making observations together with knowledge from literature. The outcomes focus on the detected issues but also touch on general best practices for project planning and scheduling. Technical challenges are given less attention regarding alternative planning tools as the target company has decided to continue using Primavera P6 for now.

In general project planning needs more resources to keep up with the growing planning and control needs of the target company. Target company's objective is planning driven execution for projects which means that the planning and control systems will need developing and big projects will need someone to use and update these systems together with a continuous communication flow in the planning process. In practice, a site planner is needed for all the update and control work in big projects. In addition, understanding of internal customer relationship is needed for the whole project organization together with knowledge management.

In the new big projects, project plans should be more like the large plan introduced in Table 1. This sort of detailed and broad schedule would need filtering and layouts for smaller sub-plans for disciplines and for other purposes such as subcontractor schedules. Moreover, the reports exported might need summarizing and thus extra effort. The benefits are significant though; accurate resource assigning together with progress tracking and therefore better forecasting.

5.1 Project planning process

Effective planning process requires involvement of all key stakeholders and the project plan is a critical communication tool. It helps managing stakeholders' expectations and keeps participants informed. During this process should be remembered that things must be planned the way they are done, not vice versa. The first thing to do is to clarify the importance of project plan and schedule for the whole organization in order to make sure people will pay more attention to these issues in future.

The initial project planning and the first schedules have been good from project management perspective. They are compact and have the necessary information needed at this stage. This is what also the Lean Project Planning and milestone planning suggests.

Too many details too far in advance almost certainly mean rework and changing the already made plans. In addition, detailed schedule made with assumptions of the project planner is not more useful than a scarce schedule presenting just frames for the upcoming project schedule. From a Lean perspective this (detailed initial planning) is just non value adding work. At initial planning the focus should be on results and deliverables. This means that the first things to agree upon are milestones representing stages to the final deliverable. After it is clear what the project is going to produce and what the stakeholders are expecting, the activities between milestones are considered. In other words, ‘what’ questions should be answered before ‘how’.

Important part in the beginning of the planning process is to define stakeholder expectations and find out if there are conflicts. It is better to settle possible conflicts already at inception than to discover these near the end of the project. This in mind, the stakeholders should be prioritized and make themselves agree to this order. In addition, at initial planning phase the scope should be divided with everyone involved and settle the WBS that everyone will use for the project. The schedule should be divided to logical phases from production point of view and it should cover at least major disciplines. Eventually, this partition should be clarified to everyone in the project organization. The modified project planning process is presented in Figure 14. From the beginning to the end better communication is needed to keep the process fluent and smooth.

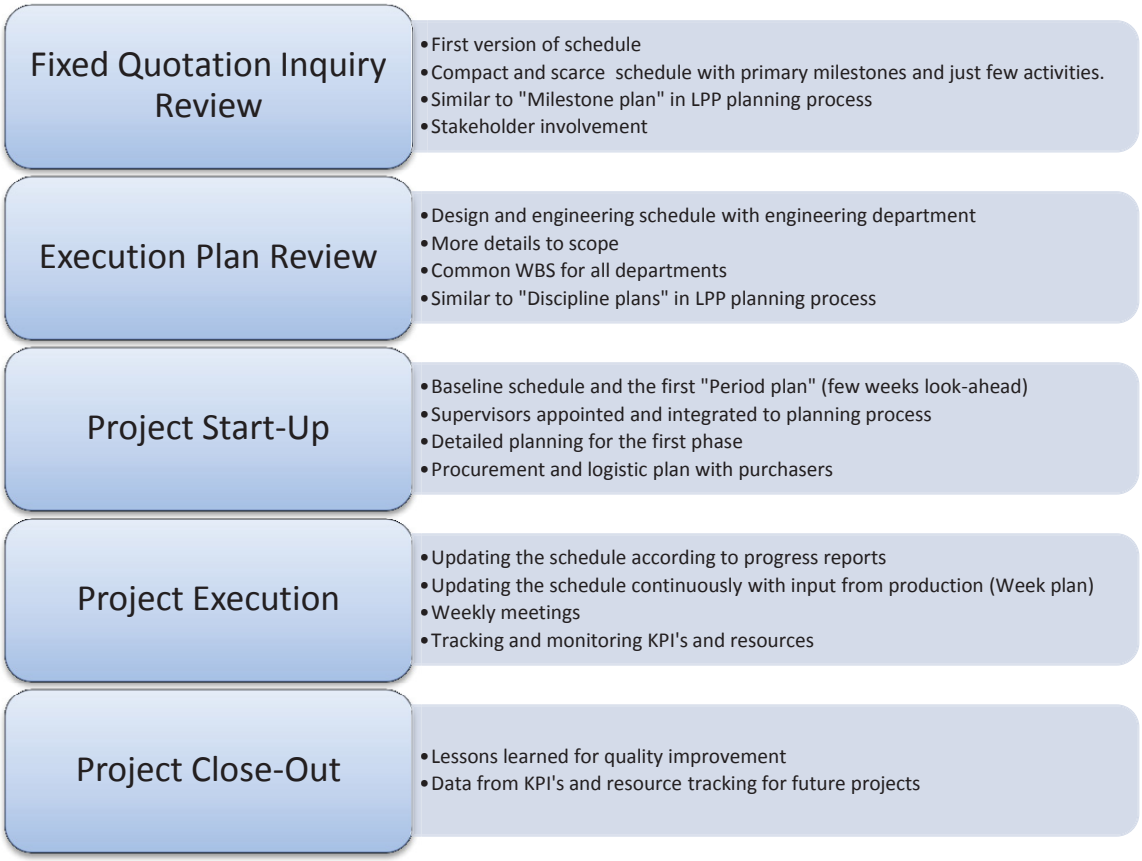

Figure 14. *Alternative project planning process*

After the contract award when baseline schedule is created, the supervisors for production should be taken into the planning process and announced for project organization matrix. This is critical to get realistic estimations about activities, durations and resources. Similarly, procurement and engineering tasks should be divided and given durations and sequence the activities with the knowledge from purchasers and engineers appointed for the project.

Before the start of construction at site, the first refinements are made to the schedule to expand details and to make the particular phase of construction reflect reality. After getting more details of the first work phase, the first look-ahead for next 5 or 8 weeks can be generated. These refinements will continue along the project execution every time before a new phase starts or new information related to the schedule is available. This technique follows the top-down method as the extension to details is done in stages and combines it with bottom-up method by using the information from earlier successful projects when such information is available.

At the project execution phase, weekly meetings are held to discuss the issues occurred and make plans to solve these. Supervisors should also keep track of their activities the way presented in LPP methods. This means listing of activities planned to finish each week and preparing to present these. These week plans for supervisors act as work lists

for them and are not extra work for them in that way. In addition, they should plan how unfinished activities, that should have been completed, are taken care of and present these ideas. Trackers and KPI's are used to monitor operations and these indicators are followed to react as early as possible to emerging risks. The PDCA-cycle from LPP is used for risk management to make issues visible, to find proper solutions, then to check the results and to act on deviations. Once the project is completed this data is used to make estimations for next projects and to avoid making same mistakes again.

5.2 Project management

More attention should be given to building the project WBS and deciding key milestones and weightings for activities. This is important as some invoices are attached to milestones and they are also used internally to monitor progress in disciplines. WBS clarifies the project's structure and enables to focus on certain disciplines or areas in the schedule. BI Publisher is also using the WBS when creating for example s-curves for different disciplines. Moreover, using a common WBS enhances communication in the process.

A site planner who updates and controls the project schedule and progress is needed. He or she takes care for all progress and KPI tracking and manages the planning system, P6. The project planner or planners are not making estimations about durations or resources for the project and its activities but this is to be done by the supervisors and other employees in the project who have the knowledge. Therefore, the key persons for planning should be announced for project organization early enough. The planner collects and supplies this information to P6 together with experience from earlier similar projects. To help in this, data collecting should be started from current projects. This can be used to estimate activity resources and durations in future projects. For example how long does it take to install one meter of pipe or duct and how many workers are needed. The planner stays in the project from the beginning until the end and in ideal situation, has experience and a good understanding about the length and feasibility of projects.

For stakeholder control and overall clarity the SBS and Three key questions from SMART planning methods are suggested. By creating the SBS, mission of a project, stakeholders together with their expectations and all tangible deliverables are defined. In the SBS, the stakeholders are ranked according to their importance and influence for the project which helps managing expectations and priorities. One important connection visible in the SBS is between the project mission and the objectives of buyer or sponsor. If this link is missing, there is no point to continue the project. The Three key questions introduced in chapter 2.1.2 are designed to check that the SBS was created properly and to bring up issues relevant to understand the project goals.

5.3 Engineering

The engineering schedule should be built with the designers and make sure it serves other disciplines in the schedule with correct activity relationships. It is not just a list of documents that will be completed but a schedule with a sequence and relationships to procurement and construction activities. Activities for engineering should be named according to their relation to production in order to see a clear critical path and to be able to sequence the activities. A list of required documents can also be in the schedule to present when they are completed.

The construction order should be planned earlier to help engineering department prioritize design work. A work planner with knowledge about the production phases should define and divide interfaces in designed areas in advance for engineering. This way the designers would only need documents of the first work phase ready at the start of construction work in a divided area. In practice this means for example a room with various work phases such as electrical installations, piping installations and ducting installations. Most times the areas are not built by only one subcontractor, thus it is not necessary to have every phase designed and documented when the first phase begins. This also reduces the number of changes needed and the amount extra work needed for designing.

5.4 Procurement

There is a lot of uncertainty in procurement planning and hence all information available is needed. Purchasers' knowledge about selected suppliers and lead times should be informed to planning without particular requests. Sharing knowledge actively is important as the planners do not necessarily know when decisions on suppliers are made. Moreover, purchasers' knowledge is needed to make estimations for activity durations, sequencing and how to divide the supplied materials in schedule. With better forecasts, thanks to more information to the schedule, more accurate material deliveries are possible to make and save on warehousing costs. Same thing applies for labor; they are not too early or too late on site if forecasts are accurate.

For procurement's progress updates the list of materials ordered should have clear categorizing and possibly more information about the items. The Product Shipment should be modified to have a column for material category. This would clarify where the item belongs in the WBS and facilitate follow up. Further, the category should be clear enough and not just 'catering equipment' for example. This could include a coffee maker and a refrigerator which have totally different effects on the schedule. However, the important thing is to make sure that those who it concerns know what the categories include. Good communication helps to make things clear.

5.5 Production

Production supervisors need to be announced and their responsibilities defined earlier to help in planning. Supervisors have a critical role in project planning as they provide data from construction phase and help defining activities, durations, sequences and resources together with reporting progress inputs. All this information is needed to update and control the project schedule and to make reliable forecasts. The forecasts are also an important indicator for supervisors themselves for example to manage subcontractors and hence they are actually serving themselves among others by providing all this information.

Activities are updated more often during the project when new phases start, changes take place and more information is available. The progress reports for planning should include more information than just progress statuses in percentages. Most important is the amount of remaining work for each activity. With P6 this can be reported in number of days remaining or by giving an expected finish date. Once the planning system has this information it can produce more reliable forecasts. With progress percentages the planning system can show how the project is advancing and Publisher can export s-curves to show the progress visually.

For more accurate look-ahead planning, supervisors should use the technique introduced in the Last Planner System. This technique involves listing activities that are going to start and those that will finish during the coming week. This is sort of a work list for a supervisor. Every week a PPC from previous week's list is calculated. This is done by dividing completed activities by those that were planned to complete. Consequently, if all planned activities for that week were completed the PPC is 100%. This indicator will give a hint of possible problems at higher level if the values are low for a while. Thus, issues in higher level and in progress can be predicted. In the weekly meetings, these uncompleted activities are discussed and plans are made to solve issues regarding them. In the target company, this concerns largely the subcontractors and their operations. Therefore, the target company's supervisors should require sufficient planning from subcontractor's foremen too. This will likely need a lot of management efforts at first but will probably become part of routine procedures eventually. Once again communication is crucial in order to succeed in this.

5.6 Progress reporting

There are two parts in progress reporting from project planning perspective. The first is receiving progress updates from different departments and disciplines and the second is sending progress reports to project manager. These progress reports for the project manager normally include the project schedule and s-curves for overall progress and different departments or disciplines. Both parts of these reporting duties are usually done weekly but it depends on what is agreed. The progress updates for project planners are

usually done with Excel sheets or orally at the office. In some cases data can be found on the software used by procurement and logistics but usually even if there is updated data, it is already outdated. The people updating this software are not aware that planners (and probably someone else too) need this information every week and thus it should be updated more often. These kinds of issues require the understanding of internal customers and contribution for knowledge management by the management.

It is clear that the quality and accuracy of the received reports in planning department affect directly to the quality and accuracy of the reports that planners will prepare for project manager and which he or she will eventually forward to the client. This is one more reason to pay attention to the progress updates. Currently there are challenges to get progress updates from all the departments and even if the reports are received they may not have all the required information. Project planners are this way forced to make requests every week to get the necessary information. In order to fix this, the management needs to make an effort to change this and get people in the organization to understand the issue. To have more effective planning and scheduling, people need to understand their role in the process.

5.7 Changes to current planning

In the suggested alternative practices, the scope is divided likewise in every department and the project schedule has this same partition in the WBS. Currently there is no common scope dividing and departments are using partitions that suit best their interests. In addition, the building phases and areas are divided earlier in order that designers can prioritize their work. This has not been possible in the current projects where designers have designed everything as early as possible and then redesigned some of the documents as changes have taken place.

Supervisors are announced earlier for the project to help in project planning. In addition, other specialists' support is used as much as possible. Consequently, project planners will do less estimation for the schedule as this is intended for the experts, in this case the supervisors. Hence, the roles have changed a little in project planning. The project planners focus now on collecting the information and analyzing it with the planning system. In contrast, at the moment the project planners are doing a lot of estimations on the schedules as there is no better information available. Currently at the initial planning phase, planners are not getting enough information as there are no supervisors announced for project organization. Thus, there are practically only few people to get information from.

The alternative practices suggest appointing of a site planner for big new building projects. Site planner is taking care of all the work that is not conceivable currently. This includes more frequent schedule updates, more accurate progress tracking and creating

KPI's for monitoring performance together with all the other things that will result from changes in the planning process.

Internal customer relationship management and knowledge management are integrated to the organization culture. These methods support the planning process overall and ensure that needed data is available for the right people. Moreover, these support learning and cooperation at the organization together with helping to get tacit knowledge in the use of planning and scheduling. Eventually, improved communication and knowledge management will affect employees' motivation and commitment to projects positively. The weekly meetings are one place where communication is crucially important and where learning and innovations happen.

6. SUMMARY AND CONCLUSIONS

Project planning and scheduling process lasts almost throughout the whole project. Thus, it is one of the most important processes during the project and improving it promotes the project success. The project planning and scheduling gives many benefits and it helps controlling the project but in order to gain advantage, it needs proper information flow and sufficient communication. The project plan and the forecasts made with it are only ever as good as the information received to create the plan. Furthermore, Emblemsvåg (2014) states that project planning must primarily be a communication process.

The suggestions for alternative practices could improve the project planning and scheduling in the target company. The planning process could proceed without interruptions and integrate the whole project organization to planning. A reliable common tool to support every department might enhance commitment for a project and motivate the whole project team to stay on schedule and to reach set objectives.

In this research, the current state of target company's project planning was reviewed and challenges in it were observed. The main challenges were insufficient communication and resources reserved for project planning. Support and help from the project schedule is needed but only a little information is given to create and update the schedule. Hence, the company management needs to integrate methods from knowledge management to the organization and promote internal communication. With these changes, the project schedule could be updated properly and the needed support would be available. Better communication for the progress reporting is needed to update the project schedule weekly. These updates are critical for creating a reliable schedule which is needed for managing a project. With a schedule that reflects reality, reasonable forecasts can be produced. These forecasts and the schedule support decision making and give employees a chance to base their decisions on something else than their own feelings. Consequently, the forecasts are important for risk management as they give an opportunity to detect emerging risks in advance and to react on these.

After getting enough input for project planning, someone to manage all the information and data is needed. This can be solved by appointing a planner to be responsible of only one big project to have enough time to focus on the project. For optimal communication and cooperation, this planner would be part of the site team.

There is not enough understanding about individuals' role in the project and how everyone's work affects someone else's tasks. Clearer and unambiguous schedule with activi-

ty chains makes it easier for everybody to understand their place and effects in the whole project. With a clear activity chain the effects of one activity to another is easier to notice and the activities on critical path are in evidence. The culture of internal customer relationship also improves the understanding of own work's importance to others.

Once communication is sufficient, knowledge transfer is easier and smoother. This makes progress updates more useful assuming that the people who fill the reports, now understand the meaning of internal customer relationship and how their reports are critical to the project schedule. With proper information from the reports, the project planner can produce a reliable schedule and further, reliable forecasts. The project schedule and forecasts are needed for several management purposes such as risk control, subcontractor and supplier management and decision making.

By appointing production supervisors earlier for the project organization, the project planner will get enough information and estimations for the project's baseline schedule and less changes are needed later during the project. With supervisors' assist the project planner can also prepare sufficient KPI trackers for the construction phase. This way the trackers would be made in line with supervisors' preferences.

As a conclusion to the first research question: "What kinds of challenges are faced in the organization and what are the root causes of these challenges (i.e. why they exist)?" this study described the organization's current state regarding project planning. To find out the underlying reasons for these challenges a cause/effect analysis was used and the outcomes were divided to three categories: human challenges, technical challenges and organizational/process challenges. From human causes, the ultimate reason was insufficient communications that lead to limited knowledge transfer and that way to other issues. Low attention to project planning and its demands was the main issue in organization and in the process. This naturally lead to other planning issues as well. From technical perspective the challenges were related to using independent follow up documents instead of a convergent one and also the lack of having a common technical solution for data management. In addition, a challenge with reporting automatization with the planning system Primavera P6 and Publisher was observed.

For the second research question: "How to overcome these challenges?" several methods and techniques derived from literature and interviews were recommended. The main improvement suggestions are from Lean and SMART Project Planning, two theories developed by experts in the field who have studied project planning. Furthermore, the concepts of internal communication and knowledge management are suggested to improve the overall performance in the organization and in the planning process.

REFERENCES

Andersen, E. (1996). Warning: activity planning is hazardous to your project's health!. International Journal of Project Management, Volume 14, Issue 2, pp. 89–94.

Ballard, H. G. (2000). The Last Planner System of Production Control. Faculty of Engineering, The University of Birmingham, pp. 191.

Becerra-Fernandez, I. (2008). Knowledge Management: An Evolutionary View, Taylor and Francis, Armonk.

Burke, R. (1995). Project Management: Planning and Control. John Wiley & Sons, pp. 4–19.

Cavusgil, S. T., Calantone, R. & Zhao, Y. (2003). Tacit knowledge transfer and firm innovation capability. Journal of Business and Industrial Marketing, Volume 18, Issue 1, pp. 6–21.

Chevalier, J. & Buckles, D. (2013). Participatory Action Research: Theory and methods for engaged inquiry. Routledge.

Clarke, A. (1999). A practical use of key success factors to improve the effectiveness of project management. International Journal of Project Management, Volume 17, Issue 3, pp. 139–145.

Colorado State University (2012). Writing Guide: Case Studies. Available: https://writing.colostate.edu/guides/guide.cfm?guideid=60

Dvir, D., Raz, T. & Shenhar A. (2003). An empirical analysis of the relationship between project planning and project success. International Journal of Project Management, Volume 21, Issue 2, pp. 89–95.

Emblemsvåg, J. (2014a). Lean Project Planning in Shipbuilding. Journal of Ship Production and Design, Volume 30, Number 2.

Emblemsvåg, J. (2014b). Lean Project Planning: Using Lean Principles in Project Planning. International Journal of Construction Project Management, Volume 6, Issue 2.

Fleming, Q. W. & Koppelman, J. M. (2005). Earned Value Project Management. Project Management Institute, Newton Square, PA.

Gardiner, P. (2005). Project Management: A Strategic Planning Approach. PALGRAVE MACMILLAN, pp. 204–248.

Grönroos, C. (2000). Palveluiden johtaminen ja markkinointi. WSOY, pp 404–435

Halse, L., Kjersem, K., Emblemsvåg, J. (2014). Implementation of Lean Project Planning: A Knowledge Transfer Perspective. Springer.

Hartman, F. & Ashrafi, R. (2004). Development of the SMART Project Planning framework. International Journal of Project Management, Volume 22, Issue 6, pp. 499–510.

Kim, Y.-W. & Ballard, G. (2000). Is the Earned-Value Method an Enemy of Workflow. International Group for Lean Construction.

Kortetjärvi-Nurmi, S., Kuronen, M., Ollikainen, M. (2008). Yrityksen viestintä. Edita, pp. 106–108.

Koskela, L. (1992). Application of the New Production Philosophy to Construction. Center for Integrated Facility Engineering, Stanford University, pp. 75.

Koskela, L. (2000). An Exploration towards a Production Theory and its Application to Construction. VTT Publications 408, VTT Technical Research Centre of Finland, pp. 296.

Kuula, A. (1999). Toimintatutkimus: Kenttätyötä ja muutospyrkimyksiä. Vastapaino.

Laihonen, H., Hannula, M., Helander, N., Ilvonen, I., Jussila, J., Kukko, M., Kärkkäinen, H., Lönnqvist, A., Myllärniemi, J., Pekkola, S., Virtanen, P., Vuori, V. & Yliniemi, T. (2013). Tietojohtaminen. Tampereen teknillinen yliopisto, Tietojohtamisen tutkimuskeskus Novi.

Lientz, B., & Rea, K. (1995). Project Management for the 21st Century. Academic Press.

Maier, R. (2007). Knowledge Management Systems: Information and Communication Technologies for Knowledge Management. Springer.

Maylor, H. (2010). Project Management. Pearson Education, pp. 242–304.

MacDonald, C. (2012). Understanding Participatory Action Research: A Qualitative Research Methodology Option. Canadian Journal of Action Research, Volume 13, Issue 2, pp 34–46.

Nokes, S., Major, I., Greenwood, A., Allen, D. & Goodman, M. (2003). The Definitive Guide to Project Management. Pearson Education, pp. 39–42.

Nonaka, I. & Takeuchi, H. (1995). The Knowledge-Creating Company: How Japanese Companies Create the Dynamics of Innovation. Oxford University Press, pp. 298.

Phillips, D. (2001). Online Public Relations. Kogan Page.

Pinto, J. (2010). Project Management: Achieving Competitive Advantage. Pearson Education, pp. 161–162.

Primavera P6 User's Guide Release 8.3 (2013). Oracle.

Smith, L. & Mounter, P. (2005). Effective Internal Communication. Kogan Page, pp. 42–157.

Taguchi, G., Chowdhury, S. & Wu, Y. (2005). Taguchi's Quality Engineering Handbook. John Wiley & Sons.

Wallace, S. (2016). The ePMbook. Available: http://www.epmbook.com/index.html

Yin, R. (1989). Case Study Research: Design and Methods. Sage Publications, Inc.